Foreword / Introduction

Shift2Rail fosters a system approach to demonstrate that the innovations that are being developed will provide the necessary breakthrough change in the European railway system in terms of improved capacity, reliability and reduced costs. To allow these changes though, there is also a need to increase the rail's attractiveness, generating sufficient growth in demand. IT2Rail is the lighthouse project of Shift2Rail that tackles this aspect. One of IT2Rail's challenges was to improve interaction between the travellers and the transportation systems, proportionating a seamless travel experience. This also brings on-board another challenge, the interoperability between transport services to provide wider services to the travellers.

With IT2Rail, the traveller is placed at the heart of the solution, which led to the development of a mobile application as interface between the traveller and the different project outputs. These set of different services that are now the building blocks for the next Shift2Rail IP4 projects in its various technical demonstrators addressing IT Solutions for Attractive Railway Services.

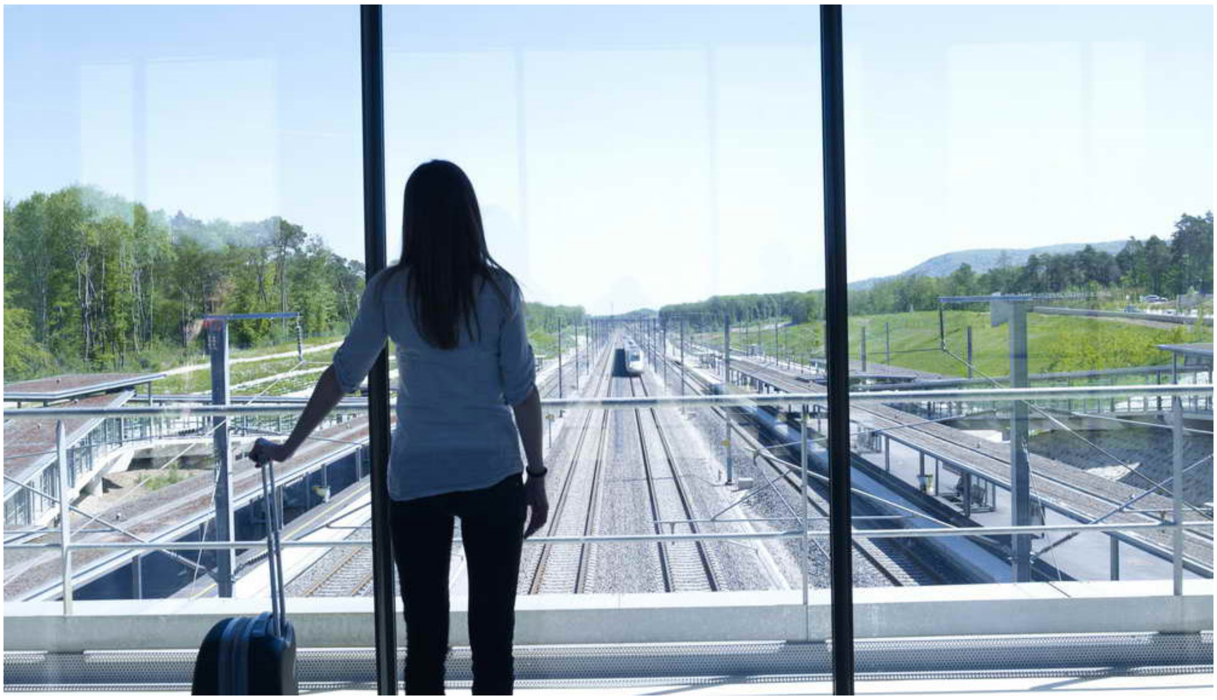
This second and final newsletter presents the main outcomes of the project with focus on the innovations that the IT2Rail ecosystem could bring to the transportation systems. These innovations will be described through the traveller's journey summarised in the following steps:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No: 636078

- creating a transport account;
- searching, selecting and booking a multimodal journey;
- getting access to the transport means;
- allowing the travellers to track their trips;
- helping the travellers to navigate inside stations;
- presenting a set of data and KPIs related to the journeys.

Now that IT2Rail has completed its work programme by breaking the complexity of transportation systems from the traveller's perspective, Shift2Rail will continue developing the concepts and technologies to achieve the goal of having attractive railway services. We are only at the first interchange of a trip that will end in 2022, do not miss the next episodes of this trip and keep informed about the progress through the Shift2Rail dissemination events and the continuing projects in IP4.

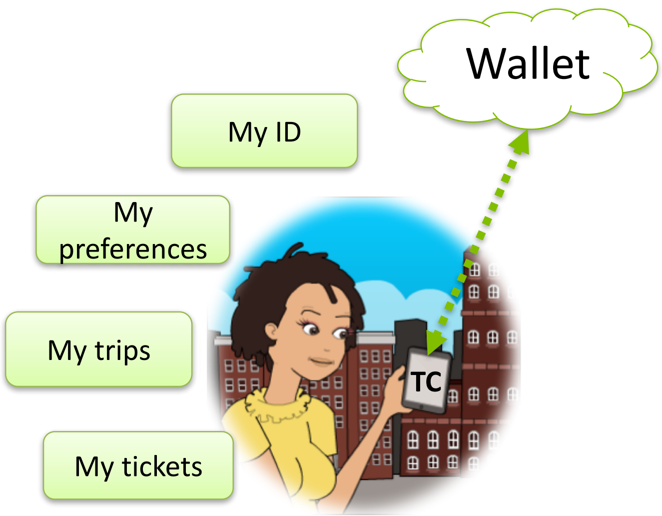
If you are interested in finding out more about IT2Rail, please visit our website at www.it2rail.eu where you can also find the contact details of the project coordinator should you need any further information.



Creating a transport account

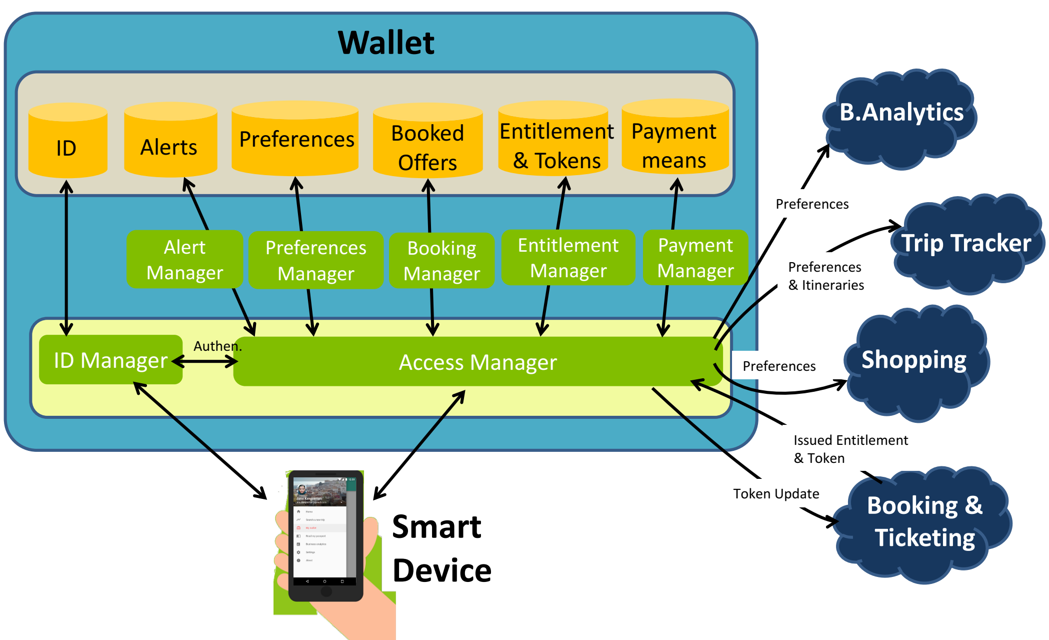
Wallet

One of the key components in IT2Rail is the **Travel Companion**, being the unified access point that grants the user access to the complete IT2Rail ecosystem and functionalities. On one side, the Travel Companion consists of a mobile application that is the interface with the user, but on the other side it also offers a "cloud wallet", a virtual space to store information related to traveller profile and trips.



On the distributed architecture implemented in IT2Rail, the Cloud Wallet is the **key point** where the information is stored and it can be retrieved by the different modules and components of the IT2Rail ecosystem, not only the Travel Companion but also other components that need to obtain user information such as the Preferences or the booked offers, or to store information such as the bookings, entitlements, tokens or payment means.

The following diagram shows an overview of the architecture of the Cloud Wallet.



The implementation of a Cloud Wallet has been possible thanks to a **modular design** approach that has allowed the distribution of the tasks between different partners, each one implementing one or several components. This modular design of the Cloud Wallet supports a distributed approach, where the different modules can be deployed in multiple servers.

The modules of the architecture, depicted in the figure above, allow the storing of, for example, user preferences, entitlements and tokens, and other trip information (departure time, modes, price, etc.). The Wallet also implements other functions, such as the **ID manager** and the **Access manager** modules that control the access to the user information. Moreover, it implements a **notification service** that is used by other components, such as the IT2Rail Trip Tracker, to inform about events related to his/her trips (i.e. trip start, disruption, delay).

Among the challenges that this type of solution faces, security and privacy are among the most relevant ones. IT2Rail proposes several solutions to guarantee security:

- Authentication mechanisms are used to allow only authorised parties to access relevant information, for the agreed purposes;
- REST API in JSON format over **https** protocol has been implemented to help guarantee **confidentiality**, **authenticity**, and **integrity** with a **trusted certificate**;
- Use of JSON Web Tokens (jwt.io) to generate **temporary authentication tokens** to access the different services provided by the Cloud Wallet;
- Important data is saved on a permanent, reliable and secure storage in the cloud using a relational database.;
- Cloud Wallet server is protected from unauthorised access using firewalls to filter traffic and ports being accessed.

Preferences

One of the key aspects of a traveller-centric travel companion is – or should be – the ability to handle and take into account the user preferences. This goes beyond the mere possibility of storing them, but also to use them to, e.g., suitably present offerings to travellers depending also on the degree with which they favour a certain option. To this end, the IT2Rail Travel Companion associates with each preference a score, which is a numerical value in an interval [min, max]. A preference with score equal to min must be avoided at all costs (for example, a user fearful of flying might set a min value to airplane as preferred means of transportation); one with max score, instead, is considered mandatory (e.g., a user might require to pay by credit card). In other words, min and max values are used to **filter** the results of, e.g., offer searches. Preferences, however, can also be assigned intermediate values in the (min, max) interval, to allow for their **ranking** (which can be performed using a variety of aggregation functions, for example by averaging the scores); in this case a value closer (but not equal) to max indicates a strong preference, while the middle of the interval (i.e., (min + max)/2) stands for "indifferent". The approach used in the IT2Rail project to handle preferences is suitably flexible to deal with the heterogeneous transportation means and concerns tackled by the project (from the search of offers to the validation of tokens).

Searching, selecting and booking a multimodal journey

Multimodal Travel Shopping

IT2Rail has put in place, albeit with very limited geographical coverage and covering only Air, Rail, Coach and Urban Public Transport (subsequent IP4 projects will target geographical / modal gaps), the fundamentals of a User shopping experience with the following features:

The User makes use of their Travel Companion 'one-stop-shop' (see One-Stop-Shop section) to access multimodal travel shopping services, and, as we have seen, using their pre-stored travel preferences;

Users no longer need to 'visit several sites' to find solutions to their mobility needs, since their portable one-stop-shop should facilitate access to comprehensive travel content;

The accessible shopping services, within IT2Rail, perform the work that today is left to the User to perform, by combining valid products from different transport modes/operators to produce a large choice of end-2-end itinerary solutions, from which the user can select for booking, payment and ticketing;

Users are relieved of having to spend time searching for appropriate transport services, and relieved of taking risks in making their own calculations of connection times between different modal services;

Their travel preferences (see previous section) may be used to filter out unwanted transport modes, or to sort the list of solutions returned to them, according to price, duration and/or number of connections;

For IT2Rail, the combinable products are the ones that are normally retailed in comodal fashion i.e. IT2Rail does not cover 'intermodal products' where the combination of different modal/ operator services are pre-combined into a single product, with a single through-fare as based on commercial agreements between TSPs (subsequent projects in IP4 will cater for this intermodal variant)

Multimodal Travel Shopping Challenges and Approaches

The high-level challenge has been to design a technical framework which could support an eco-system of supply-chain players in which the channelling of comprehensive transport products and services from multiple transport modes could be concentrated into ubiquitous one-stop-shops (see One-Stop-Shop section).

Whilst there are non-technological based obstacles to the absence of one-stop-shops today, clearly the significant obstacle, within the technology domain, is the high cost of interoperability between links in the supply chains i.e. the heterogeneous formats and protocols for the dissemination of timetables, availability and pricing data, from different modes/operators, results in very few (if any) one-stop shops, because of the very high cost of implementing and managing this heterogeneity. And this is the case, even if there were facilitating public transport policy or TSP strategies favouring the distribution of transport products to third-party retailing operations (which there are not).

The application of a semantics technology approach to achieving interoperability in the transport sector, as introduced by IT2Rail, is a major innovation, and promises to significantly remove the technology cost barriers for consolidating and aggregating content.

Other challenges have centred on addressing operator concerns about the treatment and distribution of their data (one obstacle to the supply to 3rd party retail operations) due to concerns about the security and quality of that data for reaching the end-User, when the supply is out of the hands of TSP proprietary distribution and retailing operations, as well as the higher cost of doing so.

With regards to the cost of 3rd party distribution, if the cost of interoperability is reduced, one might hope that this reduction could be passed on to the TSPs. For the quality and security issues, the approach in this instance has been to comprehensively reject a forced or prerequisite centralisation of data and processes within a single centralised platform.

The philosophy of the approach has been to facilitate the access to data wherever it happens to reside (no moving data around or collecting it for central storage – except where this is already in place and is a TSP agreed feature of legacy supply chains e.g. in the AIR sector) and to facilitate the access to expert processes e.g. journey planning, availability and pricing processes, wherever that resides in connection to the formal presentation of that raw-data in TSP itinerary offers. This has been achieved by interlacing the Shopping Process with access to Resolvers such as the Travel Expert Resolver (see Interoperability Framework section) which provides the Shopping Process with the knowledge of who and how to access directly the relevant TSPs and/or their contracted and approved aggregators and journey planning processors. The opportunity for maintaining the quality of data provision which direct distribution channels allow for should therefore be equally available via indirect distribution channels. Additionally, whilst not formally introduced in IT2Rail, subsequent projects in IP4 plan to use the semantics technology to establish an access capability which takes into account any TSP-agreed access as reflected in today's Sales Licensing and/or Distribution Agreements which the TSP maintains with its supply chain partners.

Together these approaches bring the benefits of a distributed architecture, data and processing such as authenticity, quality and no single point of failure.

One stop shop

Definition:

The One-Stop-Shop is identified as the 'elemental' unit of a future Single European (multimodal) Transport Area (SETA). The ubiquity of one-stop-shops in the future is required to underpin the EC white paper on transport vision of one-click access to pan-European seamless travel ultimately from door-2-door.

The IP4 vision also encourages and facilitates direct distribution-retailer TSP operations, where multimodality may be limited to complementary rather than competing transport services from different transport modes.

Concretely, this means concentrating access to all the data and processes required to complete the advance purchase of co-modal (IT2Rail) or intermodal (later in IP4) Travel Entitlement(s) (or 'tickets') from shopping through booking, payment, ticketing and after-sales including re-accommodation (in case of service disruptions), within a single point or 'one stop shop' i.e. the Travel Companion – which will be commonly linked with a single one-stop-shop retailer, but may also be linked with several one-stop-shop retailers and/or dedicated TSP one-stop-shop retailer outlets.

One-Stop-Shop Challenges and Approaches

As mentioned above for multimodal Travel Shopping, the high level primary obstacle resides in the cost of interoperability, at least in the technology domain. Booking and Ticketing models and processes vary considerably between transport modes and may vary between operators within a mode. Once again, in 3rd party distribution supply chains, this acts as a significant break on consolidating these processes within a one-stop-shop: it is even an obstacle to the 'direct distribution only TSP' who nevertheless attempts to increase market share by combining its products and services with complementary products and services from other modes.

As mentioned above, the semantics technology approach drives interoperability costs significantly out of the equation, opening the door to greater connectivity for supply chains in general, leading to considerable opportunities for the one-stop-shop to become a norm within the market-place.

Other significant challenges for the user today consist in the booking and ticketing phases, where these processes need to be managed across different sites with the frequent risk of transport services becoming unavailable in the time it takes to successfully book preceding segments of the journey (which may be non-refundable!).

The IT2Rail one-stop-shop Booking and Ticketing services will deploy algorithms which maintain contextual knowledge of the multiple booking and ticketing dialogues, so that in the event of a single failure, roll-back processes may be invoked in order to avoid leaving the user with partially booked or partially ticketed itineraries, and consequently avoid severe issues with cancelling now useless segments and obtaining refunds.

Interoperability Framework

Advanced ICT solutions that can provide a truly customer-centric one-stop-shop experience for multimodal travelling across the Single European Transport Area must overcome the technical challenge of distributed computing: the ability to coordinate the execution of complex computational tasks that are inherently distributed on multiple heterogeneous systems, or "nodes", of an open network with no central control. In this light, systems are interoperable if they are capable of participating in such distributed computing tasks.

Conventional approaches to the solution of this problem have concentrated in the past on altering artificially the essential features of the distributed computing landscape

- The adoption or regulation of common formats and protocols for inter-process communication aimed at removing heterogeneity;
- The local importation of remote data sets (data exchange) aimed at removing the distributed nature of data resources;
- The centralised governance of participant actors in the scope of multimodal solutions aimed at controlling the openness of the network.

While designed to reduce the complexity of the technical challenge, these approaches reduce interoperability to controlling the movement of data sets across the network. However, they generate high costs in the adaptation of existing systems to common formats and protocols, in the administration and maintenance of these formats and protocols to keep them common in the face of changing requirements, and in forcing participants into a centrally synchronised roadmap for the deployment of solutions.

In contrast, the IT2Rail project has recognised one-stop-shopping for multimodal travel solutions as a natively distributed computing problem.

The "nodes" participating in a travel shopping, booking and ticketing process instance are independent "Travel Experts", which control local resources embodying the "expertise" of a specific Travel Service Provider Company about the travel solutions it provides, e.g. itineraries, modes of transport, prices and ticketing options. Shopping, Booking and Ticketing "orchestrators" developed in the project build a full solution that matches a specific Customer requirement by accessing and combining resources provided by Travel Experts over the network.

Definition:

The Interoperability Framework encapsulates the «mechanics» of interoperability across the networked heterogeneous Travel Experts. It uses «semantic interoperability» principles and technology, described below, to achieve the following **innovation objectives**:

- insulate IT2Rail applications such as the Shopping and Booking orchestrators from the heterogeneity of Transport Service Provider systems, providing an abstraction, the "web of transportation", of the distributed data and computational resources available over the network;
- Minimise or eliminate altogether the need for adaptation of Transport Service Provider systems to become part of a network of services available to Customer experience applications;
- Minimise the need for static exchange of data sets;
- Minimise the need for centralised deployment roadmaps.

Semantic Interoperability refers to the ability of interacting computers to automate the interpretation of the data they process regardless of how this data is structured or exchanged. Knowledge about the domain problem, which is typically held by human analysts and programmers, is formalised in a set of logical statements, or "axioms", written in a standard computer language available for machine processing. Human knowledge is thus transferred to machines and shared by them. Any particular representation of concepts and relationships in a specific data structure is associated, through a process of annotation, with its interpretation in terms of the domain problem. Machines can therefore discover and leverage equivalence relationship between different data formats with common meaning, and automate, therefore, the translation across these formats. Automated computer logical inference replaces human programming of software to operate on different but equivalent data formats however they may be exchanged.

Implementation:

The Interoperability Framework is built on the principles of the ISO/EIC 10746 standard for Open Distributed Processing systems, using open source frameworks, allowing for multiple concurrent deployment options that can be tailored to specific operating environments. It exposes a set of specialised «**Packaged Resolvers**», i.e. web services for use by IT2Rail applications to provide specific functionality.

- **Location Identification** returns geographical coordinates of Locations that a Traveller requests by name;

- **Locations Resolver** returns a list of Stop Places within a requested radius from a point specified by its geographical coordinates. It is used during the Shopping process to identify transportation stops in the vicinity of Locations selected by Travellers from the list returned by Location Identification;

- **Network Statistics Provider** generates « meta routes » operated by Transportation Service Providers. These «meta routes» are elements in the construction of meta-network used by the Shopping process;

- **Travel Expert Resolver** identifies Travel Expert and Booking Engine web services that can generate offers and bookings for specified «meta travel episodes» that satisfy a Traveller's mobility request at the time of Shopping and Booking. It is used by the orchestrators to identify the subset of networked Travel Experts that participate in a coordinated distributed shopping and booking one-stop-shop instance;

- **Navitia Decoder** associates Stop Places and Transportation Services with the encodings used by the Navitia platform for use by Trip Tracking in the identification of disruptions;

- **Travel Expert and Booking Engine Brokers** mediate the interaction between the Shopping and Booking orchestration functions, respectively, and the Travel Expert or Booking Engine services provided by Transport Service providers for the generation of offers and bookings that satisfy the Traveller's mobility requests. Using semantic interoperability inferences, they perform the appropriate data transformations.

All «Packaged Resolvers» use a common underlying framework that handles the semantic interoperability mechanism described above and is controlled by inference rules and configuration information stored in the Interoperability Framework's **Asset Manager**.

The Interoperability Framework **Assets Manager** provides the tools that allow independent Transportation Service Providers to participate in the «web of transportation» environment:

- The **Ontology Repository** stores the domain's knowledge represented as first order logic statements in the OWL language;
- The **Semantic Web Service registry** contains web service descriptors of the services exposed by participating Transport Service Providers, e.g. Travel Experts, Booking Engines. Descriptors are associated with semantically annotated data structures and inference rules that are used by the semantic interoperability mechanism to automate the conversion across different data structures;
- The **Triple Store** contains semantic graphs that describe resources such as Stop Places.

The **Assets Manager** supports workflows for versioning, approval and publication of shared resources such as the Ontology or Web Services descriptors.

Achieved objectives:

Objective	Achievement
Mask interoperability «mechanics» to Applications	Seven heterogeneous systems interoperating with zero changes to data structures or communications protocols
Cut cost and time for TSPs to participate in providing multi-modal travel solutions without a coordinated «roadmap» for deployment	New independently developed shopping and booking providers added to interoperability scope during the project
Operate with existing data structure specifications	Ability to work with a subset of NeTEx CEN/CENELEC data standards (Stop Places) demonstrated
Allow for multiple concurrent deployment options that can be tailored to specific operating environments	Interoperability Frameworks deployed simultaneously on multiple web server containers. Automated semantic conversion libraries configured to be deployed simultaneously in brokers, at client or at server sides.

Getting access to the transport means

Decouple the traveller's "rights to travel" (Entitlement) from the "means used to travel" (token/embodiment) needed for validation during the journey

Challenges solved:

At the heart of IT2Rail, **Ticketing systems** are one of the major enablers of multimodal transportation. Such systems are often based on legacy systems where access control and fare product consumption often require a specific technical infrastructure for the fare media (e.g. contactless smart card, magnetic ticket), transactional security, access gates... Lots of efforts are currently being put to achieve interoperability between such systems at regional scale and national scale.

At the European level, IT2Rail interoperability aims at solving fare media fragmentation (i.e. having numerous contactless smart cards) by unifying the fare media into a single one. It also aims at creating interoperable fare products by defining products that every actor of the eco-system has to support and implement. Such interoperability is very interesting for the traveller but presents some major drawbacks.

- **Problem**: the larger the eco-system, the harder it gets for all stakeholders to cooperate in a competitive environment (and create interoperable products). If the considered scale is Europe-wide, it is clearly an issue;
- **Problem**: it is a rather costly approach as legacy systems have to be adapted to handle the common fare media and fare products. This can be a blocking point for small public transport operators.

Solution: IT2Rail has chosen to take a complementary approach to ticketing interoperability inspired by the air industry and the rail mainlines, where ticketing interoperability is independent from such technical infrastructure constraints. This approach is contractual: it aims at formalising the relationship between the transportation eco-system and the traveller by defining business processes with open specifications and interfaces and defining business artefacts shared between systems. In detail, the "ticket" is transformed into a set of three elements: The Entitlement, the Token and the Embodiment.

Innovation:

The Entitlement is a representation of the contract between customer, traveller and transport service provider. It is the main element of interoperability; it must be accessible and readable by every party involved. It provides the traveller with the rights and duties regarding his/her travel. It identifies the actors involved and provides the traveller with information on every operation related to the contract (e.g. It lists the fare products that can be used for an identified itinerary).

The Token is the translation of the Entitlement into the technical infrastructure of the transport service provider. It is the element that is needed by the traveller to perform the travel. This element is dependent on the legacy equipment involved. This is why the Token payload (a part of the Token) is not standardised. It can take as many forms as ticketing systems (e.g. the application of contactless smart card, a QR-Code image, etc.). In IT2Rail the Token payload is associated with standardised metadata referencing the way it has to be used. The payload and the metadata together constitute the Token.

The separation between the Entitlement and the Token allows transport service providers to collaborate on one entitlement (terms and conditions of the contract) while maintaining their specificities expressed in the Token.

The Embodiment is the physical object that supports the Token. It is used in the ticketing system for the validation process and interfaces itself with the ticketing system access systems (such as gate, bus validators etc.). The Embodiment has the necessary capabilities to interact with the ticketing system and therefore varies according to the ticketing systems (e.g. a contactless smart card, a magnetic ticket, a printed QRCode, an NFC Phone and more). With IT2Rail, the Embodiment is not standardised but instrumented. The Instrumentation of the Embodiment is the formal description of its communication and computation capabilities. This allows ticketing systems to take advantage of the internet of things – dynamic interfaces enabling computation of the necessity or not to issue a fare media for the traveller.

For example, determining at the time of purchasing if a customer NFC Phone has the capability to emulate a contactless smart card or if the ticketing system must issue a physical contactless smart card.

The separation of the Token and the Embodiment allows different deployments between token and embodiment and, in the end, the virtualisation of the fare media whenever possible. This interoperability scheme has some interesting and innovative characteristics:

- First the IT2Rail ticketing interoperability allows legacy systems to remain fully functional taking full advantage of each ticketing system's specificity;
- Secondly, it scales up horizontally as it is not intrusive in its constituents;
- Lastly, it allows mutualisation whenever possible by composition of fare products into an Entitlement, composition of Entitlements in an itinerary or mutualisation of the Embodiments.

Allowing the travellers to track their trips

Multimodal trip tracking

The main objectives of trip tracking services are to:

- Listen to the on-line information on traffic irregularities;
- Alert travellers to all relevant events affecting their itineraries;
- Propose alternative solutions in response to such exceptions.

To achieve these goals in the multimodal ecosystem supported by various providers of travel services, the Trip Tracker had to face a couple of challenges.

<u>Challenge:</u>

Identification of sources of disruption information

When processing the tracking activation request, a set of monitors capable of listening to various sources of disruptive events is instantiated. To do so, the Trip Tracker needs to identify such sources. However, most current approaches to the challenge of informing Passengers of disruptions that affect their itinerary and/or provide alternative solutions are based on the concept that the Transportation Provider that performs the transportation service also:

- Defines conceptually the disruption information it provides, e.g. a "delay";
- Provides this information for the transportation service it performs, but is unaware of the possibility that this service may be integrated in multi-operator, multi-modal overall passenger itinerary;
- Defines and implements its own protocol for providing the information both technically and logically.

Support to an actual Passenger may therefore be very limited. For example, since the Transportation Provider is only aware of disruptions that occur in its transportation service, it is blind to the fact that it may need to provide an alternate solution as a consequence of a disruption in either a previous or subsequent episode in the overall itinerary even if the episode it services is running regularly.

<u>Innovative solution:</u>

In contrast, the IT2Rail Trip Tracker component is designed:

- first, to be aware of the Passenger's overall booked itinerary;
- second, to discover sources of relevant disruption information, which may be outside of the domain of control of a single Transportation Provider;
- and third, to provide the component with sufficient information about the nature of available disruption information, as well as the technical protocol used by the source to communicate this information (how to connect to the source, which data format it uses for the exchange, tools or procedure to convert heterogeneous data formats).

This is achieved by a combination of two elements:

- Available sources of information are described digitally through semantic annotation by a "web service descriptor" stored in the Semantic Web Services registry;
- Semantic annotations are used to operate on the data formats to automate the process of converting data with the same "meaning" across different formats.

This allows the Trip Tracker component, in conjunction with the Interoperability Framework, to find the digital description of a service that can provide specific disruption information, and then use this description to connect to the source and operate on the available data.

Challenge:

Correlation of IT2Rail itineraries through the available data (decoding)

The identification of Sources of Disruption Information as described above provides the underlying mechanisms allowing the Trip Tracker component to evaluate possible disruptions for the whole itinerary across all involved modes and transportation providers concurrently. However, since available sources are normally only aware of their specific episode and their specific data elements, an additional mechanism has been introduced to correlate the Passenger's itinerary information to these specific data elements. i.e. "decoding" the itinerary information, based on their common semantics.

Innovative solution:

In the course of the project, it has been determined that this approach is theoretically sound and feasible, but its accuracy, while acceptable for the scope of the IT2Rail "pilot" demonstration, would not be sufficient in more generalised use cases or more complex scenarios and needs to be complemented with additional techniques based on artificial intelligence, e.g. machine learning algorithms. Such algorithms would be able to discover correlations (or 'decodings') that cannot be completely described axiomatically. However, the scope and budget of the IT2Rail project have been found not to be sufficient to pursue this additional line of research, which should be pursued in the continuation of the Shift2Rail IP4 Innovation Programme. In IT2Rail, the more common library-based self-learning algorithm of decoding/encoding have been implemented instead.

Challenge:

Analysis of disruptions on multimodal trips

As noted above, once the tracking of a given itinerary is activated, the traveller is kept notified on all known travel conflicts that may affect the planned journey thanks to listening to various disruptive events sources performed by activated monitors concurrently. Such events are processed by the Complex Event Processing. However, to enable the evaluation of an impact of the disruptive event on the whole itinerary across all involved modes and to assess whether an alternative solution has to be proposed, an innovative evaluation mechanism independent on the disruptive event source, travel episode affected by the event and the mode of transport involved in the travel episode had to be introduced.

Innovative solution:

The impact assessment is based on matching disruptive events with rules. Within processing of tracking activation, itinerary details are transformed into rules. However, the level of impact is evaluated in 2 steps (generic vs. user-dependent rules matching). This mechanism enables processing of incoming disruption information streams sequentially and identifying possible travel conflicts to the extent of the whole itinerary.

Three levels of impact of a disruptive event on the itinerary can be recognised. In the case of the highest impact on the itinerary, i.e. when the itinerary cannot be followed anymore, the traveller can ask for alternative solutions. These solutions are suggested by the Travel Shopper, which at that moment may not be aware of the reason of why the re-accommodation is requested. Therefore, before the offer of alternatives is delivered to traveller's device, it goes through an internal check first and is shortlisted accordingly. At the end, the offer of alternatives is displayed in the device, so the traveller can choose the most suitable option and continue travelling without any worries.

Helping the travellers to navigate inside stations

Indoor Navigation: A challenge if no infrastructure is allowed

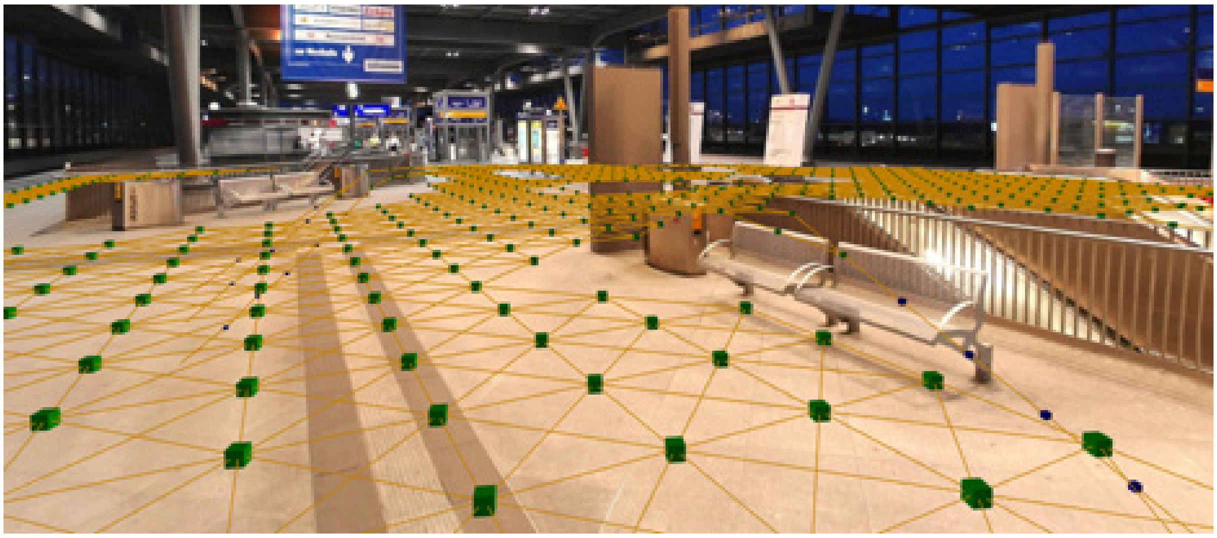
Challenge:

For outdoor navigation, the use of GPS is still state of the art and a worldwide used standard, but it is challenging for IT2Rail to have indoor navigation, as there are no GPS, WiFi, dedicated placed QR-Codes on walls or dedicated placed iBeacons.

Innovative solution:

A system from NavVis is considered a solution to this challenge. It is a visual based navigation system, that matches the current user's view to a surrounding area that has been mapped beforehand. In order to generate these visual maps, a so-called Trolley with laser technology is used, which is accurate up to 5mm. With this device, three dimensional pictures are taken every meter. It also measures not only WiFi but also iBeacon signals if they are available.

By matching the already mapped area with the image recordings of user, a Navigation Grid can be determined. In order to enable navigation and mapping without a complex infrastructure as well as to use real coordinates, this model to be developed here is geo-referenced.



The Navigation Grid in turn is base for the Navigation Graph

Presenting a set of data and KPIs related to the journey

Data-driven process for enhancing Travel Experience

Challenges solved:

An interest from non-ICT businesses is growing across the economy related to technologies and services required to exploit data as an important resource for value creation and for fostering new products, processes, and markets. Consequently, the exploitation of data and analytics can create significant added value in the transport and travel domains. Data generated by any system or organisation is revolutionising the economy as it is the platform from which every business has to start, the key instrument of the ecosystem for the present and future. The remarkable increase in the volume and complexity of available data requires a combined multi-disciplinary approach to design an overall strategy aimed at transforming data into useful information.

- **Problem**: Management of huge amount of information collected from heterogeneous sources.

  Solution: Big Data platforms to process information and manage structured and unstructured data.

- **Problem**: Mining business insights from travel data for transport operators.

  Solution: Data-driven approach applied to information can leverage machine learning techniques and advanced business intelligence tools in order to enhance the services offered by operators transportation systems/travel agencies.

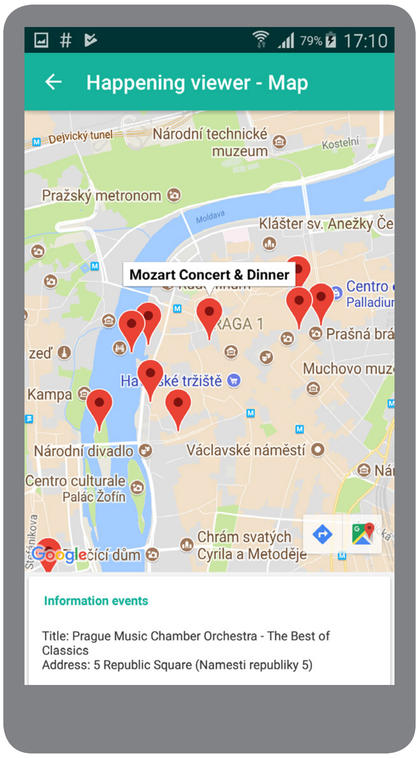
Innovation:

The activities carried out within the Business Analytics work package aimed at developing prototypes in order to demonstrate the enhanced advantages provided by a data-driven approach with machine learning techniques. To this aim, several research & developments goals have been achieved, such as:

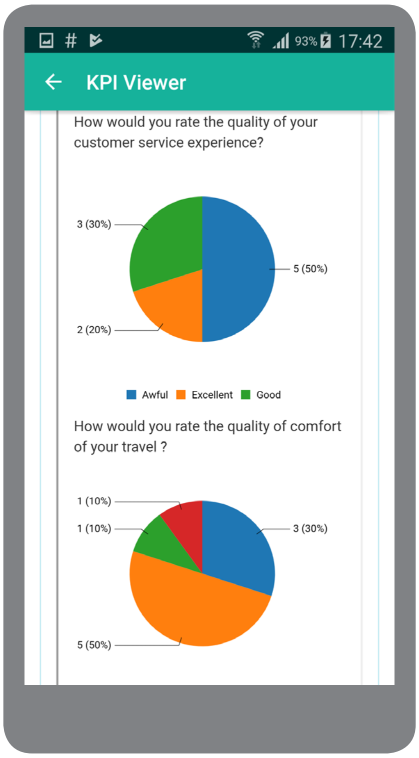
- Implementation of mechanism to mine users' preferences in order to suggest and tailor options depending on the context in which the users are;
- Development of specific software modules in order to assess travel comfort related services. This assessment consists in air quality inference in underground public transport stations based on meteorological measurements and forecast;
- Analysis of the feedback and reviews provided by the travellers and realisation of a Research & Development activity by studying specific supervised machine learning algorithms applicable to text analysis.

Furthermore, traditional business intelligence tools have been improved by leveraging the capabilities of novel technologies embedded in the Business Analytics platform. To this aim, the IT2RAIL partners have integrated their platforms to achieve the following results:

- Leverage of the capabilities of the SOFIA platform by adding new dashboards which show KPIs computed on the data collected from WP3 (Booking & Ticketing), WP4 (Trip Tracking) and WP5 (Travel Companion);
- Implementation of software modules in order to compute KPIs on messages retrieved from social network platforms by respecting users' privacy;
- Usage of tools belonging to a Big Data suite which enabled to compute KPIs concerning user satisfaction and performance of multimodal transport systems. These KPIs are based on data retrieved from internal and external data sources (e.g. weather, happenings etc.)



Happenings viewer advise the travellers on how to organise their journey.



KPI viewer also provides indications concerning the quality of travel services experienced on board by travellers.

Facts and Figures

Total Budget:

€12 million

(€12m EU funded)

27 Partners

Duration:

36 Months

Project Start Date:
1st of May 2015

Project End Date:
30th of April 2018

Grant Agreement N°:
636078

Partners

Project coordinator

www.it2rail.eu