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ATTRACkTIVE

Advanced Travel Companion and Tracking Services

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Abstract

Shift2Rail, a Joint Undertaking European initiative in the railway industry, is composed of five Innovation Programmes. Of these, the fourth one addresses “IT Solutions for Attractive Railway Services”. This Innovation Programme shall offer a seamless, stress-free, and even engaging experience for travelling. ATTRACkTIVE as one of the IP4 projects expands and further develops solutions of the prior lighthouse project IT2Rail in order to guide, support, inform, and potentially entertain users throughout their entire journey. It aims to provide new concepts, tools, and systems to improve the attractiveness of rail transport by offering more intuitive and engaging travel experience for travellers, while shielding them from the complexity and heterogeneity of services for door-to-door intermodal journeys. This includes disruption handling, navigation and user centric ubiquitous applications; as well as the required tooling and modular design of the system to foster adoption and to enable future refinements, new concepts, and ideas.

Keywords: Customer Experience; Positioning; Guidance; Traveller Experience; Deviation Recognition; Preferences; Cloud-Wallet; Distributed Services; Trip Tracking; Extensible Architecture.

1. Introduction

Shift2Rail is a Joint Undertaking founded by a partnership between the European Commission and the Founding Members, which includes the main stakeholders in the European rail sector. Its mission is to boost innovation in the rail sector over the next few years; accelerate the integration of new and advanced technologies into innovative rail product solutions; promote the competitiveness of the European rail industry; and meet changing European transport needs. Research, Development and Innovation carried out under this initiative will aim at achieving a Single European Railway Area (SERA) and enhancing the **attractiveness and competitiveness** of the European railway system to ensure a modal shift from roads towards a more sustainable mode of transport such as rail. The three Key Targets, which are expected to be reached as results of these activities, are depicted in Figure 1.

Fig. 1 Key Targets

Within Shift2Rail, the Research, Development, and Innovation is focused on five pillars or Innovation Programmes (IPs) that include innovation in areas such as Rolling Stock, Signalling, Infrastructure, and Freight. One particular IP is focused on increasing the attractiveness of rail transport by developing novel and integrated solutions for the travellers. The main goal of this IP (IP4 – "IT Solutions for Attractive Railway Services") is therefore to provide a radical improvement to the current inability to perform a door-to-door trip as a seamless multimodal journey, aligned with the challenge of the European Commission´s White Paper for Transport (2011): "By 2020, establish the framework for a European multimodal transport information, management and payment system" of the Shift2Rail project.

Works in this area started in 2015 through the IT2Rail project, which is a first step or "Lighthouse" towards the long term IP4. Its ideas are continued and further developed to a higher level of readiness in the associated Shift2Rail projects. Among these, this paper is focused on the ATTRACkTIVE project, aimed at enhancing the traveller experience through customer experience applications, providing a unified access point to the whole transport ecosystem (the "Travel Companion") and providing information relevant to the journey (navigation services, information of disruptions, etc.).

Whereas ATTRACkTIVE focuses the attention on user experience, other complementary IP4 projects tackle other areas that are needed to improve the attractiveness of rail transport and shield customers from the complexity and heterogeneity of services for door-to-door intermodal journeys. Among them, the Co-Active project must be highlighted. It started in parallel with ATTRACkTIVE (September 2016), and is aimed at complementing the traveller-centric focus of ATTRACkTIVE by introducing shopping and ticketing functions for new urban transport modes; researching booking and ticketing functions (post-sales – cancel/re-shop/rebook/refund) to assist in re-accommodation of the travellers following any critical service disruption as notified by Trip Tracker; and proposing innovative solutions for settlement-payments amongst Transport Service Providers (TSP) involved in providing services for a traveller's multimodal itinerary.

However, user experience applications delivered by ATTRACkTIVE, and multimodal travel services delivered by Co-Active, are only the "visible to the user" part of the transport ecosystem that IP4 is building. Beyond them exists a technical framework and a set of tools that will foster the digital transformation of rail and in general all the transport ecosystem, enabling efficient interconnection and data sharing between heterogeneous systems. Dedicated projects to these topics have already started, including ST4RT, GOF4R (started in September 2016) and CONNECTIVE (started in September 2017). All on-going and future IP4 projects will work aligned and coordinated in order to deliver altogether the expected results of IP4. The ongoing project COHESIVE will assure the integration of all different project outcomes and a coordinated, smooth and efficient interface amongst project components and modules.

Next sections will present in more detail the objectives of ATTRACkTIVE and the works done within this project.

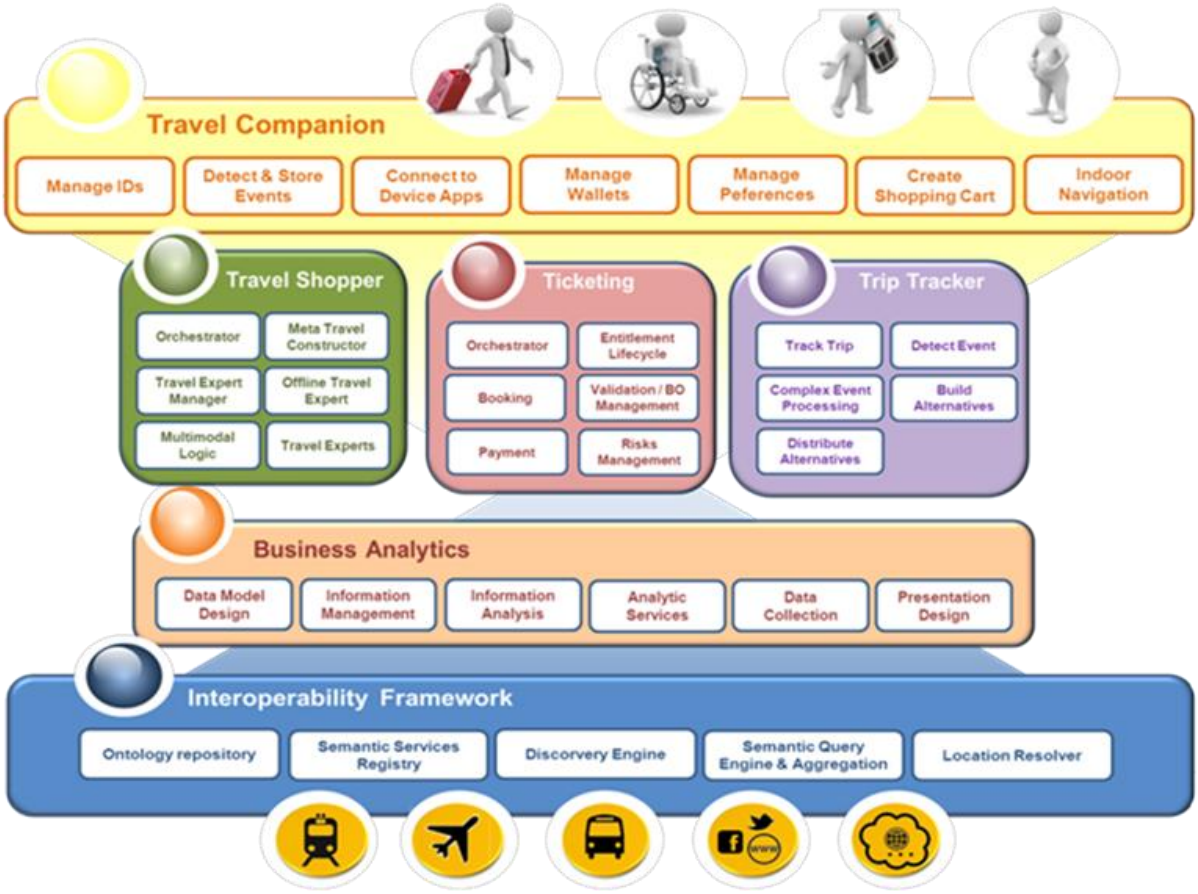

Fig. 2 Main Functions

2. Inspiration of ATTRACkTIVE

A real life journey, taking a traveller from door-to-door, is almost always a set of elementary journeys that combine several transport modes. In some cases, especially when the starting point and destination are not on the same transport service, a journey can become a little bit complex.

Let's take a basic example of a simple door-to-door travelling: Georges is living in the suburb of Grenoble (France) and he wants to travel to Amsterdam (Netherlands). He will first need his personal car to reach the local railway station from his home before taking a train from Grenoble to Lyon. From Lyon he will take the TGV train to Paris. Since the Thalys train to Amsterdam is starting from another railway station, Georges has to take the metro to connect these two railway stations within Paris. Arriving in Amsterdam, a short walk to hotel will finish this trip.

As we see in this example, a typical trip today is multimodal and will most likely involve different modes like walking or personal transport modes in general beside the "classic" public transport modes. Personal transport mode is normally also required to manage the entire door-to-door journey in order to make the journey easier for the travellers. Taking this mixture of transport modes into consideration, it is obviously necessary to manage the entire door-to-door journey in order to make it easier and more comfortable for the travellers to move around. Increasing the attractiveness of the railway and in general of the transportation services requires helping the users for the preparation and the organization of the travel as well as during the travel itself.

In order to prepare the travel from Grenoble to Amsterdam in a passenger-centric and friendly approach, Georges needs to be able to define his multimodal travel door-to-door in one place without looking to the specific website of every potential transport operator involved in the journey. Buying multimodal travel in a one-stop shopping process will be a huge feature for Georges who we assume is looking for simplicity and efficiency. The challenge that exists preparing for such travel is the reality of shopping and booking different modes under one travel solution. Georges' preferences should also be managed and taken into account in order to provide transport services, which are well adapted to his current needs and expectations.

Whilst "en route", there are a lot of opportunities to help and to inform Georges during each of his "travel episodes" - the smallest segments of the journey. Smart navigation, adapted to each travel episode, is provided through the Travel Companion. This relies on the Trip Tracker which monitors Georges' progress in real time and collects myriad information that could understand future impacts to his travel. Georges will be pleased to know that he will find a free parking place for his car in a car park near to the railway station of Grenoble. At the railway station Georges will appreciate being guided to the platform by the most direct means, something especially useful at large or complex stations.

Precise indoor and outdoor localisation of Georges during his travel is the condition to offer him accurate information on his environment. By offering information related to the available shops and activities provided in and near the railway station, correlated with the time Georges has to wait in the railway station, he can usefully or pleasantly spend his connection time. Entertainment will also be offered to Georges to pass the time in the train. This makes the journey more seamless, stress free, engaging and ultimately more attractive than a long drive through the congested streets of the city.

Before the travel starts and during the travel, Georges will be informed if the travel arrangements are modified in any way and if the travel is impacted, or even disrupted. In that case the best alternative solution will be defined and implemented in an easy way whether the new solution is multimodal or not.

The situation of Georges is most common in nowadays daily life. ATTRACkTIVE attempts to present solutions that guide him all along his travel behaviour and thus will bring a clearly better attractiveness to plan and travel by using all possible transport means.

3. Advanced Functions and Principles

Within ATTRACkTIVE there are two domains where new functionalities will be developed: the Travel Companion and the Trip Tracker.

The Travel Companion is the assistant that will help and guide the travellers along their journey and, as such, is the unique interface between them and the Shift2Rail ecosystem. In order to fulfil its objective; it is made of two complementary parts. The first part is the mobile application that acts as the interface with the users and the second part is cloud based services to store personal data and provide the gateway to the entirety of the Shift2Rail services.

The mobile application, also called Personal Application, is the client which a traveller can use to access the whole ecosystem. In this way, he is able to access all services through a homogenized user interface, allowing him to leverage all the capabilities of the system while being shielded from the complexity and heterogeneity of different services.

The online counterpart, known as the Cloud Wallet, is central to the Shift2Rail architecture as it serves as the secured repository for the users' personal information. It acts as a bridge between the Personal Application and all of the external services by allowing two way communications.

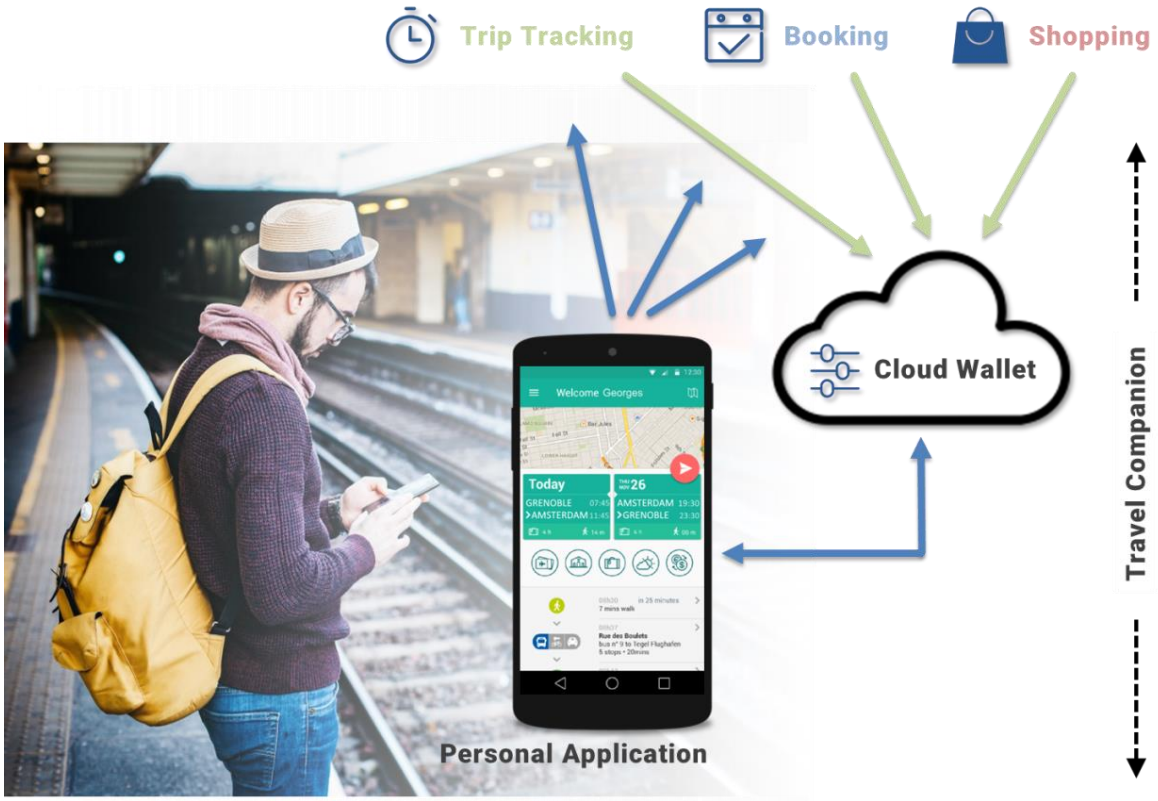

Fig. 3 Advanced Functions

3.1. Travel Companion - Personal Application (TC-PA)

Nowadays, mobile devices such as smartphones and tablets are becoming the preferred means of access to many services, especially transportation ones as these are often accessed "on the go". Moreover, the two most used mobile operating systems in Europe are Android and iOS. In order to answer the needs of the majority of travellers, as well as to research strengths and potential limitations of both systems, the Personal Application will target both environments. This is why it will build on top of the results of the lighthouse project IT2Rail and expand the scope of the functionalities it covered.

One major challenge of the Personal Application is to expose the numerous services of the IP4 ecosystem in a consistent manner, when these services are developed by different partners. Moreover, as the program extends across several consecutive projects, the results of ATTRACkTIVE aim to be reused and improved. In order to meet this need, it is structured in a modular way, to allow both the easy creation and integration of new modules and the upgrade of existing ones.

Furthermore, in order to satisfy the growing need of transport stakeholders to monetize their facilities by offering entertainment and sponsored content to their customers, an entire aspect of the project is focused on enabling partners to create Location Based Experiences and deliver them to the users in a targeted fashion, when they are relevant to his itinerary.

The Travel Companion, through its different modules will offer the following main functions:

- Managing users' account and preferences stored in the Virtual Space of the Cloud Wallet (see section 3.2).
- Automated collection of sensors' data, such as Bluetooth or WiFi scans.
- Manual input from the users, solicited when a possible disruption is detected or candidly supplied.
- Feedback of collected data to the Trip Tracker to improve real time information gathering.
- Push of real time information and disruptions about the itinerary to the travellers, through system notifications, even when the mobile application is not running.
- Navigation, including outdoor and indoor positioning and guidance at interchanges.
- Automatic delivery of rich content through dedicated Location Based Experiences (see section 3.1.2.1).

3.1.1. Module based framework

The framework of the Personal Application consists of several elements, some of which are software components and others are technical guidelines to follow. First of all, it offers a development environment and a library that enables modules to register themselves in the application and display entries in menus or dedicated pages. Secondly, it provides a common stylesheet that modules have to use to harmonize the graphical user interface. Finally, it includes guidelines that need to be followed to standardize technical implementations such as inter modules communications, background services and battery drain mitigation.

These elements will accelerate the creation and especially integration of new modules in the future.

3.1.2. Two main modules using the module based framework

3.1.2.1. Location Based Experiences

Location Based Experiences can range from automatically offering retailer discounts to a traveller when they are in a specific station and have enough time before the train's departure; to proposing a complimentary Video on Demand service to every passenger of a train network if it's prepared accordingly. In order to support this wide range of possibilities, we supply a visual editor that allows the easy creation of said experiences by select transport stakeholders and the ability to make them available to every user of the Travel Companion.

The mobile application is then in-charge of evaluating the relevance of the experiences, suggesting them to the traveller and executing them.

3.1.2.2. Navigation: Positioning and Guidance

Positioning a traveller along their trip whether they are on a train, aboard a bus, on the street or in a metro station at an interchange is obviously a corner stone to the provision of Location Based Experiences. The area of localisation (eGNSS, magneto-inertial, beacons, etc.) is moving at fast pace so this task will start with a study of suitable positioning frameworks keeping in mind Technology Readiness Level (TRL), performance, cost, maintenance/upgrade/upscale criteria, and openness of positioning module architecture.

Software techniques and 2D/3D cartography of the traveller environment will be applied to optimize positioning quality: availability, accuracy and indoor/outdoor transitioning.

A first positioning framework will be designed in this project, provisioning and integrating the selected software and hardware techniques in the Travel Companion to achieve indoor/outdoor positioning complying with the requirements and constraints identified in this initial study.

Guidance at every part of the travel is an essential milestone for a seamless door-to-door experience. Within ATTRACkTIVE, a seamless door-to-door navigation will be introduced. This consists of:

- Guidance at interchanges, first and last mile: route description and stepwise instructions for the next turns.
- Guidance at public transport: information for entering, staying and leaving vehicles.
- Guidance at private transport: information to fetch and return vehicles; route description and stepwise instructions for the next turns.

3.2. Travel Companion – Cloud Wallet (TC-CW)

It is usual for specific travel modes, such as in the airline industry, to store passenger data (name, contact details, itinerary, ticketing details) in back-office services. Other modes, such as urban metro or bus, have not widely adopted this approach nor do they identify a traveller when validating tickets in general. There is however a clear trend to adopt the air transport model for other modes of transport, identifying users and storing their preferences and personal information thus enabling provision of improved and personalized travel services and fares. However, the multiplication of service providers and the lack of standardisation results in multiplication of registration and accounts for users. Moreover, information available to one service is not available or irrelevant to others.

This situation will be overcome with the creation of a ***User Virtual Space*** to store information from travellers such as user unique identifier, profile, preferences and special needs, but also entitlements acquired and journey details, allowing travellers to receive information affecting their journey as well as providing ubiquitous access to travel rights in **electronic wallets**. This concept boosts the "dematerialization" of travel and ticketing services, which entails to substitute most paper and cards for a single media (such as mobile phone) in which all travel tickets and trip information is stored electronically, which is key for achieving new and improved operations in ticketing and validation in **multimodal environments**.

ATTRACKTIVE approach is to build the User Virtual Space in a **cloud infrastructure** that guarantees scalability, high availability, and low latency. It provides storage through web services interfaces (such as REST, SOAP), and allows ubiquitous access to data to the users and to different transport services. *Federated identity management* and *single sign-on* mechanisms are being implemented in order to allow single user authentication process across multiple systems or services, providing users with a single traveller account (to which they can sign on through their Personal Application), and making its information available to different transport services that will use it to provide services tailored to users´ preferences. The sensitive and confidential character of information stored (personal details, credit card information, trip details) makes it necessary to provide mechanisms to protect them and the access to them, guaranteeing that all legal measures are taken, and protecting users from unwanted attacks .

This way, when travellers use their Travel Companion and start a "shopping" process in order to learn the best option to travel from home to a hotel at their holiday destination, the necessary components in charge of finding the best itinerary and offers will consult the User Virtual Space and take into account users´ preferences and needs in their search, keeping this process transparent to the users. This also allows the users to receive real-time information, relevant to their journey, as itinerary information is also stored (together with tickets information) at the Virtual Space. It also guarantees that users can have access to all travel information from any media connected to the Internet. This is commonly a "smartphone" interface but in the future it could be smartwatches or other upcoming devices.

3.3. Trip Tracker (TT)

Before and during the journey, travellers would like to be informed about any unforeseen situations immediately and automatically be offered with alternative routes if necessary or at least to inform the travellers how the situation can be handled. This challenge will be tackled by the Trip Tracker being in charge of collecting travel related information from multiple sources, to detect and handle transport events and disruptions for all modes and to provide travel tracking services.

Following the idea of a module based framework the architecture of the Trip Tracker itself is modular and developed as a distributed system. The idea is to facilitate individual partners to provide their information as source for sophisticated solutions in case of a disruption or predicted possible disruptions to travellers. These so call partial Trip Trackers will be treated by the Tracking Orchestrator responsible to inform the users and to propose them individual solutions for their current situation.

3.3.1. Tracking Orchestrator

The Tracking Orchestrator (TO) manages the tracking of a journey, by making use of several partial Trip Trackers collecting their information related to that journey. In order to do so, the TO disassembles a journey into several parts (geographically and content-related), looks for appropriate partial Trip Trackers and instructs them to track these parts of the journey. From that moment on, they are responsible to forward any information that might affect the journey to the TO. Every time one of the assigned partial Trip Trackers signals a status change of its **partial journey**, the TO evaluates the impact for the **complete journey** and generates a new status of the journey. Status changes which are relevant for the users are then signalled to the Travel Companion.

The Tracking Orchestrator is responsible for tracking a whole journey. It obtains the journey from the Travel Companion on request of the traveller. Its interfaces are based completely on a publish/subscribe schema. The Travel Companion always subscribes the whole journey to the TO and the TO publishes status changes for this journey to the Travel Companion. The TO subscribes a partial journey to a partial Trip Tracker and the partial Trip Tracker publish status changes for this partial journey to the TO.

In detail the Tracking Orchestrator contains the following sub-components:

- **Journey Subscription Manager**: Provides a service where a client (usually the Travel Companion) can activate a tracking for an already computed journey. It follows the publish/subscribe schema. The client subscribes to relevant information changes for this journey and the Tracking Orchestrator publishes them. Through the same service, the client can de-activate, pause, and re-start the tracking. Additionally, the settings of the tracking can be changed. The Journey Subscription Manager keeps track of all journey tracking subscriptions and its respective clients.
- **Tracking Activator**: Triggers the activation of all partial Trip Trackers responsible for their partial journey respectively. In addition, after the tracking of a journey is activated by a client the Tracking Activator has to collect relevant preferences for this tracking request. It uses the partial Trip Tracker Resolver to generate a list of partial Trip Trackers suited to track the journey with the given preferences.
- **Partial Trip Tracker Resolver**: Decomposes the whole journey into partial journeys in order to allocate them to a suitable partial Trip Tracker. The partial Trip Tracker Resolver makes use of the Interoperability Framework and its knowledge base of the capabilities of partial Trip Trackers (geographic coverage, modes, functions, event types). It tries to cover all travel episodes of the journey and all requested event types with its choice of partial Trip Trackers. Usually more than one partial Trip Tracker will cover the journey. Moreover, several partial Trip Trackers may be used for a single travel episode of a journey.
- **Partial Trip Tracker Subscriber**: Subscribes the respective partial journeys to the responsible partial Trip Trackers. The partial Trip Tracker Subscriber manages and keeps track of which partial journeys are subscribed to which partial Trip Trackers for which event types. It handles also the un-subscription.
- **Event Processor**: Receives incoming impacts from partial Trip Trackers. An impact is a pair of an event and an affected partial journey. The Tracking Orchestrator only receives such impacts. The appropriate matching of events to partial journeys is done by partial Trip Trackers. The Event Processor maps a received impact to its corresponding journey and evaluates the current state for the journey (regarding all received impacts until now). For this evaluation the transitions between tracked partial journeys also have to be checked. The transition itself is checked by the Tracking Orchestrator.
- **Notification Generator**: Checks whether a change of a current state of a tracked journey is relevant for the subscribing client. That is when the underlying impacts affect the travellers and are noteworthy. Depending on preferences and previous notifications, relevance and noteworthiness may vary.

3.3.2. Partial Trip Tracker

The objective of partial Trip Tracker (pTT) is to provide the Orchestrator with impacts that will affect the journey for which the tracking was requested, accounting travellers' preferences.

As a journey may have several modes of transport in a multimodal environment as in the ATTRACKTIVE project orientation, the need for several different pTT has been found. With that goal in mind, the trip tracking architecture was designed in a way that several pTT may coexist, processing events and providing impacts in different domains, being:

- Infrastructure Management events (e.g. Roads closed, …),
- Weather events (e.g. Heavy rain, Hot weather, Hail, …),
- Mobile Devices Sensors and User Reported events (e.g. Overcrowding, Delays, …),
- Multi events,
- Special transport modes,
- Specific area for public transport (e.g. a city).

As several trip tracker solutions already exist, the architecture also contemplates integration of those solutions, either as an event source for an existing pTT or as a specialized pTT.

The main functions of the pTT are to:

- Divide a given partial journey into several travel episodes.
- Find the relevant event sources for each travel episode.
- Process the events collected from each event source according to the preferences provided by the Orchestrator.
- Feed the Orchestrator with the impacts resultant from the events processed.

The result of this approach is a fully adaptable tracking environment prepared for expansion with a need for minimum development.

3.3.3. Prognosis

The objective of the prognosis functionality is to enrich the IP4 multimodal ecosystem with the ability to predict possible future irregularities, such as delays or service disruptions. The now-casting (borrowing a weather forecasting terminology that indicates predictions in the near future) of such situations that can affect the traveller journey can ensure a prompt reaction allowing the system to propose alternatives that mitigate or cancel the inconvenience.

In the overall architecture the prognosis functionality is carried out by several components, each of them generating predictions on different contexts. From the Trip Tracking point of view they act as special event sources generating predicted events that are inferred by the analysis of other events.

Within ATTRACkTIVE descriptive analytics approaches will be used to now cast the status of moving assets; prediction algorithms will use a combination of real time and historical data in order to generate predicted events.

4. Summary and Outlook

The Shift2Rail initiative aims to foster the whole rail industry to improve existing and to provide new sophisticated solutions with the goal to use rail instead of road. Within the Innovation Program 4 of Shift2Rail that addresses “IT Solutions for Attractive Railway Services” the ATTRACkTIVE project aims to provide new concepts, tools, and systems to improve the attractiveness of public transport. It will reflect modern travel behaviour of citizens taking not only public transport modes into consideration but also private transport modes. This opens the door to assisting users and travellers throughout their whole journey from the starting point to their destination.

In order to establish this approach the most important objective of ATTRACkTIVE is to shield customers from the complexity and heterogeneity of services for intermodal journeys. Beside this, travellers are deserving of support during their whole journey and this is as well addressed. Features include:

- Disruption handling and related alternative provision, navigation and user centric ubiquitous applications as well as required tooling.
- Offering more intuitive, seamless, stress-free, and engaging experiences to travellers, so that the journey shall become more attractive for them.

In addition openness and sustainability is considered by choosing a modular architecture for the system. This guaranties easy adoption and enables the incorporation of future refinements, concepts, and ideas. With this design the competitiveness of the public transport industry is inherently part of the solution.

In the next step the outcome of ATTRACkTIVE will be brought together with parallel projects within Shift2Rail IP4 to establish the complete IP4 ecosystem, containing all necessary functions for attractive travel services.