FIRST CONCEPTUALIZATION OF CHOICE CRITERIA AND INCENTIVES

Deliverable D2.1

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PARTNER	COUNTRY
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CONTENTS

LIST OF FIGURES

Contract No. 881825

LIST OF TABLES

1. EXECUTIVE SUMMARY

The deliverable presents the first conceptualization of choice criteria and incentives for multi-modal travel offers defined by Ride2Rail.

To support this first conceptualization, a comprehensive literature review and analysis of relevant research projects dealing with Offer Categories, User Preferences, and Incentives is presented (Chapter 5).

Since the Ride2Rail conceptualization of choice criteria and incentives aims to contribute to the activities of the Shift2Rail IP4 work programme, the IP4 terminology linked with the scope of the project is identified and analyzed. The deliverable (Chapter 6) describes the methodology adopted for the alignment of the Ride2Rail conceptualization with the terminology currently used in IP4 projects, finalized through the support of CFM partners in the 1st Ride2Rail-IP4 Collaboration Meeting.

Considering the performed state-of-the-art analysis and IP4 terminology alignment, the first conceptualization of choice criteria and incentives is proposed as an extension of the current IP4 glossary (Chapter 7). Moreover, a draft list of new components that should be implemented to deal with the defined concepts in the IP4 ecosystem is presented. Finally, concrete instances of choice criteria and incentives are described in terms of: (i) a preliminary catalogue of Offer Categories; (ii) additional User Preferences to extend the ones currently managed in IP4 solutions; (iii) recommendations for the definition of incentives to multi-modal travel offers and some concrete examples.

According to the DoA, the proposed conceptualization will be validated through a survey. The results of the survey and the final conceptualization of choice criteria and incentives will be described in "D2.4: Final conceptualization of choice criteria and incentives".

2. ABBREVIATIONS AND ACRONYMS

CFM	Calls for Members
DL	Dissemination and exploitation leader
DoA	Description of the Action
EL	Ethical leader
EU	European Union
FS	Financial Statement
GA	Grant Agreement
H2020	Horizon 2020
IP4	Innovation Programme 4
OC	Open Call
PC	Project coordinator
PM	Project manager
PMO	Project Management Office
PMT	Project Management Team
PO	Project Officer
QAC	Quality Assurance Committee
S2R JU	Shift2Rail Joint Undertaking
TD	Technical Demonstrator
TL	Technical leader
WP	Work Package
WPL	Work package leader

Contract No. 881825

3. BACKGROUND

The present document constitutes the Deliverable D2.1 “First conceptualization of choice criteria and incentives” in the framework of the WP2, task 2.1 of Ride2Rail project (S2R-OC-IP4-01-2019).

It contributes as well to WP2, task 2.3 and WP3, task 3.1 of Ride2Rail project (S2R-OC-IP4-01-2019).

Contract No. 881825

4. OBJECTIVES/AIM

This document describes activities and outcomes on the first iteration of T2.1 (WP2) for the definition of choice criteria and incentives for journey planning in the door-to-door multi-modal scenario addressed by IP4.

The deliverable provides an outline of the state-of-the-art on the conceptualization of offer categories, travellers' (users') preferences, and incentives. The report is the result of reviewing related works, considering the literature, deliverables from other relevant research projects and, in particular, outcomes from other IP4 projects.

The state-of-the-art analysis and the alignment with the current IP4 terminology contribute to the first conceptualization of choice criteria and incentives, and to the identification of a catalogue of concrete instances for the defined concepts.

5. STATE-OF-THE-ART ON CHOICE CRITERIA AND INCENTIVES

This chapter presents the outcomes of the performed analysis on the state-of-the-art related to Choice Criteria, i.e., Offer Categories and User Preferences, and Incentives for multi-modal travel offers. To obtain a comprehensive report and to involve Ride2Rail partners, the following methodology has been adopted.

As a first step, a ***preliminary assessment*** of the terminology was done during the kick-off meeting of the Ride2Rail project (11th-12th December 2019) to better define the scope of the task. In particular, for each term, the following specification for the related conceptualization task was proposed:

- *Offer Categories*: conceptualization of classes to be used to categorize multi-modal journey offers matching a given mobility request (e.g., the cheapest offer, the most environmentally sustainable offer).
- *User Preferences*: conceptualization of 3 types of user preferences
  - stable preferences (e.g., TSP fidelity cards owned by a user),
  - contextual preferences (i.e., user preferences when specific conditions occur),
  - one-time preferences (i.e., the preferences that can be expressed for a single mobility request).
- *Incentives*: conceptualization of incentive mechanisms to promote specific offers.

Once having circumscribed the scope of the task, a ***collaborative exercise*** was used to gather interesting potential contributions. Considering each term defined above, the WP2 partners were asked to provide inputs on a shared document considering 4 different dimensions:

- *State-of-the-art*: literature, articles, reports or project deliverables to be considered.
- *Experiences*: positive and negative experiences encountered by partners in similar
- project activities.
- *Risk and Barriers*: potential negative aspects that should be taken into account in the analysis.
- *Who to involve*: list of potential experts or additional figures to be involved in the analysis.

As a result, the content of the shared document has been analyzed to identify a list of potential material, experts and projects to be further investigated. The identified list of potential contributions was used as input for the ***assignment of tasks*** to the partners parallelizing the activities. Each partner was assigned with a subset of the identified sources, was asked to analyse them further and to provide contributions.

Finally, the ***drafting of a summary report*** describing the analysis carried out was produced highlighting useful insights for the conceptualization activity. The materials received were collected, harmonized and divided into the three main sections related to the three topics considered, namely: *Offer Categories* (Section 5.1), *User Preferences* (Section 5.2) and *Incentives* (Section 5.3).

Last but not least, in Section 5.4 we identify recurrent patterns in the analysed state-of-the-art on the conceptualization of choice criteria and incentives.

5.1. Offer Categories

The analysis of Offer Categories focuses on understanding what are the classes that can be used to cluster multi-modal offers provided to a user.
In Section 5.1.1, solutions found in literature and outcomes from other projects identifying a set of possible Offer Categories are proposed. In this deliverable, the set of identified categories are used for a twofold goal: on one hand, they support the identification of a Ride2Rail conceptualization for the Offer Category term (Section 7.1.1), on the other hand, they contribute to populate a comprehensive list of categories that can be used in the IP4 context for the classification of different multi-modal offers proposed to the user as a result of a journey planning activity (Section 7.3).
In Section 5.1.2, contributions defining which are the important variables to be considered as discriminants in the clustering process are discussed for a subset of potential Offer Categories. In Ride2Rail, these contributions help in better defining Offer Categories with different facets and can also support activities in WP3 for the determination of algorithms classifying multi-modal offers.

5.1.1.Offer Categories Identification

This section collects contributions on the identification of Offer Categories for multi-modal offers and it is organized dividing contributions from the literature, and contributions from European projects with the direct involvement of Ride2Rail partners.

Studies and Surveys on Offer Categories Identification

The work by Clauss and Döppe in [30] analyses and summarises a comprehensive group of factors mentioned or used in previous research to identify discriminants in users' travel mode choice. The proposed factors are clustered in three groups: instrumental, affective and symbolic.

- *Instrumental*: convenience, cost, door-to-door ability, easy to use, flexibility, healthy activity, local availability, planning effort, physical effort, reliability, flexible route choice, service degree, sustainability, temporal flexibility, traffic safety, transportability, time efficiency, weather dependency.
- *Affective*: autonomy, comfort, freedom, fun to drive, privacy, relaxation, personal safety, social exchange, stress.
- *Symbolic*: identification, prestige, status.

Each factor can be considered as a variable to categorize a set of offer categories. Moreover, as a result of an empirical study based on the previous user preferences and clustering the results, the authors propose some additional variables for providers of innovative multimodal options, such as high privacy routes, low stress, flexible route choice, high autonomy or combinations of the previous categories.

Zhao in [35] proposes a structure for analyzing travellers' preferences and explores many factors that may influence travel behaviour. The proposed structure identifies a set of variables that can be also used to categorize travel offers, reporting their measurability capabilities for each variable analyzed. In particular, two macro-areas can be interesting to cluster offers: the area based on variables referring to the *level of service* and the area referring to *perceptions.*
The *level of service* macro-area considers variables such as travel cost, travel time (riding, waiting, walking), transfers, parking availability, etc. These variables can easily lead to the definition of categories since they are well monitored and widely used in quantitative models.
The *perceptions* macro-area considers variables such as safety, reliability, convenience, level of information, crowding, cleanliness, comfort, visual, pedestrian friendliness, etc. These variables can lead to a categorization of travel offers but, as pointed out by the author, it is difficult to obtain useful data since they are rarely systematically, or consistently, monitored and new technologies only recently started to effectively help with these measurements.

The report by Golightly et al. [12] offers hints about human factors in using transport systems in the UK. Data in the report focus on factors influencing users' choices and suggest some important and not common objective aspects to categorize travel solutions. A first possible categorization is related to door-to-door solutions minimizing distances to be covered between start-end points in the user request and the exact starting-finishing locations of travel solutions found. Another possible category is related to the optimization in the number of travel episodes, i.e. offers related to travel solutions minimizing the number of changes between different vehicles and transport modes.
An additional observation is related to the possibility of categorizing travel solutions based on historical or real-time data, on public transport overcrowding/disruptions, or on road traffic.

The literature review by Hansson et al. in [13], analyzes service quality attributes (as defined in the EU standard EN 13816:2002, plus cost) of *regional* public transport (in contrast with local/urban public transport) and their influence on modal choices and customer satisfaction. It thus focuses on travelling between separate urban areas or on rural areas made on a regular basis. As a result of this study, four quality attributes have been identified to be the most relevant:

- *Cost* and importance of an integrated fare system,
- *Comfort* (in particular, on-board comfort was found to be the most important for long time travels),
- *Time* in terms of punctuality and travel time (to a lesser extent),
- *Availability* in terms of frequency and network coverage.

The identified quality attributes can suggest categories that can be relevant for users in choosing between different offers. The category of cheapest offers is clearly important as suggested also by other works, however, it is interesting to consider offers that can leverage an integrated fare system, reducing the number of travel passes that should be purchased by the user to complete the travel.

Contract No. 881825

Additional possible categories emerging from the analysis described are: a category based on historical punctuality data concerning a given solution, a category considering actual travel time also with respect to waiting for time/transfers needed within a single solution, categories considering frequency and flexibility of different solutions in terms of adaptability to changes in the departure time or the final destination.

The study by Wei and Cornet described in [32] identifies a set of factors that users recognize as positively contributing to the choice of a carpooling solution. Despite being focused on a specific travel mode, the identified aspects may lead to the identification of more general categories for multi-modal travel solutions. The factors identified are listed in order below.

1. *Environmental*: Help the environment and society, feeling 'green'.
2. *Time efficiency*: Convenience, save travel time.
3. *Sharing costs*: Share vehicle expenses or transport costs.
4. *Socializing*: Enjoy travel with others, meeting people, or networking.
5. *Comfortable*: Comfort (not crowded or noisy).
6. *Multitasking*: Get work done or phone calls while travelling.
7. *Relaxing*: Relax while travelling e.g. not having to drive.

It is important to point out, as done by the researchers publishing the study, that the results obtained may be biased due to the target survey sample composed partly of university staff and students working closely with sustainability topics.

The work by Gal-Tzur and Barsky in [2] describes the attempt by the Tel Aviv-Yafo municipality to promote the use of sustainable transport modes. Specifically, this project exploited AlterNative by ZenCity, an application for trip planning based on different criteria that can be used to categorize multi-modal travel solutions. In particular, together with the shortest/cheapest offers, it can also identify offers minimizing CO_2 emissions (environmentally sustainable) and offers maximizing calories consumption (healthy).

The master thesis work by Lem [18] on motivating city-commuter to carpool offers an analysis of the different factors and policies influencing travellers choices. The thesis pays special attention to commuting trips in the direction of congested inner-city areas of cities with more than 75,000 inhabitants in the Netherlands. Commuters' preferences are collected using a stated preference experiment in which the solo car drivers are invited to compare their current travel mode with a hypothetical carpool alternative. The results of the analysis suggest that the most influential attributes are the distance of the carpool meeting point from the current location, the travel time and the cost of the trip. Even if these factors are measured in the context of carpooling, they suggest the importance, for a user, of identifying offers that are closest to their location, take the least amount of time and are the most affordable ones. Moreover, the thesis proposes an interesting discussion about the mixed results obtained for the factor "number of people in the vehicle". On one hand, the presence of a large number of people reduces the ride price for a single traveller and can be valued for sociality aspects, and on the other, many people negatively value this aspect because it demands proximity between strangers in the car.

The MoTiV project

The MoTiV project[1] is an on-going Horizon 2020 project that collects door-to-door, multimodal data on the perceived experience of travel. The project designed a concept for 'worthwhile travel time' and implemented an app-based survey for obtaining feedback on actual trips, across all types of modes of transport – including car-sharing and bike-sharing. The application also includes an automatic trip and mode detection algorithm, prompting users to answer questions on the quality of their time spent travelling, their activities onboard and the factors that contributed positively or negatively to their travel experience.

The project demonstrated, with empirical data, that, from travellers' perspective travel time is not necessarily wasted: travellers may find the trip itself to be productive for work or personal activities (e.g. by working on a mobile device or making phone calls), provide an opportunity for fitness (e.g. when cycling to work), or simply be enjoyable (e.g. dozing off while watching the view or socialising with other passengers). The project already collected data on 70.000 trips in 8 European countries.

In MoTiV, the concept of quality of the experience is decomposed in three types of value: *productivity, enjoyment* and *fitness*. This means that, in theory, a traveller could see a real value in the time that can be spent being productive, exercising or simply in enjoying the trip. *Productivity* can be related both to work or personal tasks. *Fitness* usually relates to active modes of transport. *Enjoyment* typically depends on the ability to engage in extra, non-travel related activities (such as working on a laptop or enjoying the view), but it can also be related to conducting the trip itself (such as riding a bike). In MoTiV, the assessment is done by the travellers themselves. Initial results, represented in Figure 1, show the following values per mode category (the scale of 'value' is from 0 to 2 below, 2 being highest). It can be noticed that in cars (private motorised modes), personal tasks and enjoyment have the highest values.
The MoTiV project proposes a way to cluster trips based on a categorization of the quality of the time spent on travelling. This can be as simple as boiling down the trip-offering expectations to a single 'worthwhileness index', or to consider various time-quality values about Productivity (personal or work), Enjoyment or Fitness a traveller can expect from a specific trip, or it could inform on a list of characteristics that can contribute to making travel time more worthwhile, depending on individual preferences of travellers.

[1] https://motivproject.eu/project-results/deliverables.html

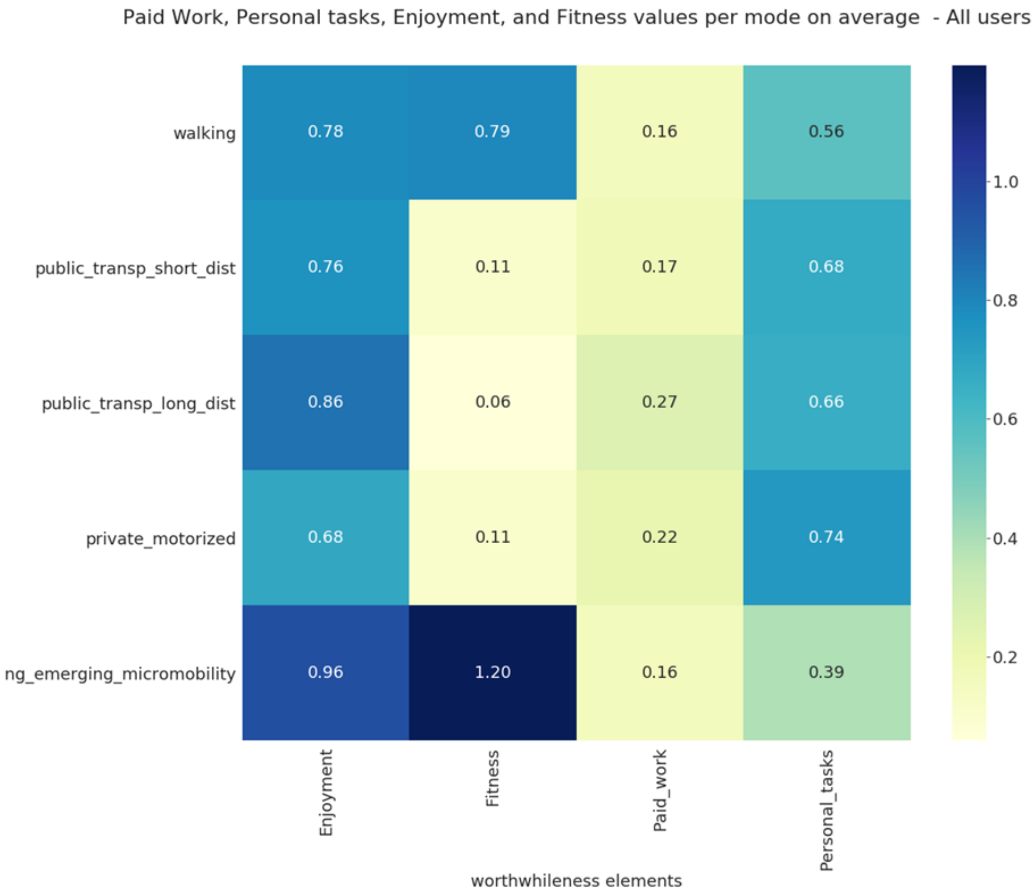


Figure 1 - Results obtained from users on travel value considering worthwhileness elements for each transport mode in the MoTiV project

A further possible categorization may be obtained considering the Dimensions of the Value Proposition of Mobility from the MoTiV project presented in [19]. The dimensions identified suggest what are the most important aspects considered by travellers in positively rating a mobility experience and can offer a way to categorize offers considering rates on the mentioned dimension:

- *Time*: To be minimized to reach destination rapidly,
- *Cost*: To be minimized (as personal expenditure) to reach the destination at the lowest cost, or to be maximized in case personal mobility plans are compatible with the possibility of earning by transporting people or goods,
- *Comfort*: To be maximized in line with travel service expectations,
- *Safety:* To be maximized to reach the destination safely,
- *Curiosity:* To be maximized in line with travel experience expectations,
- *Prestige:* To be maximized in line with social status aspirations,
- *Pro-social:* To be maximized to maintain and/or extend personal social relationships (e.g. it may involve volunteering/charity activities),

- *Well-being:* To be maximized in line with health and well-being aspirations and objectives. This includes also the commitment to reduce the environmental impact of transport (in terms of CO_2 emissions).

The BONVOYAGE project

The BONVOYAGE project[2] is a Horizon 2020 project focusing on the optimization of multi-modal door-to-door transport of passengers and goods. The main outcome of the project is related to the design and implementation of a platform providing also functionalities to offer personalized travel solutions to the user. As detailed in the related deliverable [5], different features are considered in the implemented algorithms for the recommendations. A subset of the identified features may also be useful to categorize the different offers:

- offers minimizing the overall travel time,
- offers minimizing the overall travel cost,
- offers maximizing the comfort level,
- offers maximizing the travel class variable,
- offers minimizing CO_2 emissions,
- offers minimizing the number of transit nodes,
- offers minimizing the walking distance,
- offers minimizing the number of distinct modality means.

The SMaRTE project

The SMaRTE[3] project is a Horizon 2020 project focusing on smart maintenance and the improvement of travellers' experience for railways. One of the outcomes of the project is a Rail Journey Experience Map addressing different aspects of the user experience in travelling by train. A list of categories has been used to compare train solutions with other transport modes, differentiating between urban and extra-urban travel.
Categories for urban travels (metro/tram, taxi, car, bus) are: Cost, Traffic, Speed, Reliability, Territorial Coverage, Number of Rides, Safety on night-times, Maintenance, Obsolete Vehicles, Parking need, Crowding, Safety (referred to accidents), Possibility to socialise.
Categories for extra-urban travels (intercity/HV train, coach, car, plane) are: Cost, Time, Flexibility, Reliability, Comfort, Eco-friendly, Safety, Accessibility, Infrastructure, Easy-to-check Information, Territorial coverage, Noise (onboard), Luggage Limit.

5.1.2. Determinant Factors

The majority of the Offer Categories considered in the previous section are classes that are easily associable to an offer given its objective characteristics, e.g. the fastest, the shortest,

[2] http://bonvoyage2020.eu/
[3] http://www.smarte-rail.eu/

etc. However, the assignment of some of them like *comfortable* or *environmentally sustainable,* given the attributes of an Offer Category, is not straightforward. Contributions focusing on variables which should be considered in assigning these categories are described in this section.

Studies and Surveys on Determinant Factors

The paper by Neveu et al. [24], despite not being very recent, offers a useful and still relevant analysis of the variables influencing people's perception on a set of four categories.
Factors influencing the perception of *Comfortable* travel solutions are:

- protection from weather,
- cleanliness of vehicle and station,
- fatigue felt when travelling,
- control of immediate surroundings,
- the feeling of personal safety,
- the feeling of privacy.

Factors influencing the perception of *Convenient* travel solutions are:

- transfers required,
- stops required,
- frequency of service,
- accessibility to means of travel.

Factors influencing the perception of *Reliable* travel solutions are:

- variability of travel time,
- waiting required,
- likelihood of accident or breakdown,
- influence of weather on travel time.

Factors influencing the perception of *Performant/Efficient* travel solutions are:

- speed of vehicle,
- total travel time,
- cost of use means of travel.

Considering the *comfortable* Offer Category, the authors of the review in [13] suggest multiple variables that should be considered (crowding, cleanliness, ventilation, vehicle condition, station facilities, seating, ride comfort, and complementary facilities, …), pointing out the difficulty of obtaining an unambiguous definition of the concept.

The MoTiV project

The MoTiV project, provides empirical evidence on the top factors contributing to a positive (worthwhile) or negative (wasted) travel experience as a Car passenger or Car driver. This type of factors can lead to the definition of specific, not trivial, categories for trips involving the use of the car. At the aggregate level, the main factors contributing to a positive experience while in a car (both passenger and drivers together) are, in this order: Simplicity/Difficulty of the route, Vehicle quality, Ability to do what I wanted, Today's weather, Parking at endpoints, Other passengers, Road quality/Vehicle ride smoothness, Seat comfort.

The most 'complain' factors are (in this order): Traffic/Congestion delays, Other Cars Vehicles, Today's weather, Ability to do what I wanted, Road quality/Vehicle ride smoothness, Parking at endpoints, Simplicity/Difficulty of the route, Reliability of travel time.

The BONVOYAGE project

The deliverable [4] describes the *Green Score Policy* developed within the BONVOYAGE project. The analysis performed provides good insights into the variables that should be considered to score the environmental sustainability of an offer. The two main variables considered are the means of transport and the number of kilometres covered. A score-for-kilometre is assigned to each means of transport: the score is lower for the more polluting alternatives and increases for those means of transport that have a low environmental impact. The overall score of a travel solution is obtained through the sum of partial scores for each mode of transport involved in the solution while each partial score is obtained by multiplying the score-for-kilometre associated to the means of transport for the number of kilometres covered.

Examples of criteria used to determine the score-for-kilometre assigned to each means of transport are described. The highest score is assigned to bicycle and "by foot" since there is no CO_2 consumption. The score assigned to the scooter was defined based on an average of CO_2 consumption between mopeds and motorcycles. A zero score was assigned to car, taxi and plane because of their high level of CO_2 consumption. Carpooling was assigned with a different score than cars since different users share the consumption of CO_2 of a single car (instead of producing CO_2 associated with different cars), achieving CO_2 savings.

5.2. User Preferences

This section analyses the state-of-the-art on User Preferences, focusing on stable preferences (e.g. user profile), contextual preferences changing with respect to different situations, and one-time preferences related to the single mobility-request.

In Section 5.2.1, studies and surveys taken from literature and dealing with traveller's preferences are reported. A set of European projects, with the direct involvement of Ride2Rail partners, dealing with user preferences are presented. Interesting insights and outputs are described for the following projects: the BONVOYAGE project in Section 5.2.2, the My-TRAC project in Section 5.2.3, the Social Car project in Section 5.2.4, and, in Section 5.2.5 the EuTravel project.

A latest and relevant contribution to the state-of-the-art conceptualization of User Preferences is provided by the work done in previous Shit2Rail IP4 project and presented during the alignment in Section 6.2.

The contributions analysed are used in this deliverable to propose a conceptualization of the User Preference concept in the context of IP4 (in Section 7.1.2), generalizing the work already done in IT2Rail, and to obtain a comprehensive list of User Preferences (in Section 7.4) that can be used to enrich the current implementation (presented Section 6.4), increasing the personalization of the user experience in the travel shopping process.

Contract No. 881825

5.2.1. Studies and Surveys on User Preferences

The work in [26] by Ricci analyses recommender systems in the context of travel and tourism. It introduces the main groups of features that affect personal travel choices and that should be taken into account to make recommendations. A first group is the one of *traveller-related* features which can be divided into two categories: *(i)* socio-economic factors such as age, education or income and *(ii)* behavioural factors that are rooted in psychological and cognitive factors of the traveller such as experience, personality, involvement. The second group is the one of *service-related* features, i.e., any factor which is related to the services and environment in general (travel purpose, travel-party size, length of travel, distance, transportation mode).

Wang et al. in [31] perform a study in Shanghai to check if travellers' preferences can be understood considering their activities on the web. In this work, they made use of anonymized mobile internet usage data (call, text message, voice mail, internet connection) to find the socioeconomic characteristics of the users. For each activity, they collected the location information, the timestamp and the category of contents of interest detected (e.g, finance, food, shopping, social news, housing, tourism, sports, car, entertainment, education, job seeking, game and health). Clustering geographical locations based on POI (Point of Interests) in the area they then identify statistically significant relationships between a traveller's favourite category of mobile internet content and the most frequent types of destinations that he/she visits. As a conclusion, also interests and favourite categories of contents of a user may be exploited in building an effective model to compute tailored recommendations.

Zhao in [35] analyses the psychological factors that influence travel behaviours such as people's personality traits, environmental attitudes, car pride and perceptions of convenience and comfort. The work offers a structure considering four main areas that should be considered in determining user preferences and the related variables:

- *Level of service*: travel cost, travel time (riding, waiting, walking), transfers, parking availability, car ownership, etc.
- *Perceptions*: safety, reliability, convenience, level of information, crowding, cleanliness, comfort, visual, pedestrian friendliness, etc.
- *Socio-economic status*: age, gender, social status, income, employment, household structure, etc.
- *Attitudes and personality*: social image, environmental attitudes, social responsibility, lifestyle, personality, etc.

The author highlights how transportation agencies fail to consider psychological factors in travel behaviour analysis. Moreover, the work discusses which variables are already measurable and used and which ones, like perceptions, attitudes and personality, are rarely monitored.

The literature review by Hansson et al. in [13] analyses service preferences in regional public transport. The report highlights an important aspect that should be considered in the definition of contexts influencing travellers' preferences. It is necessary to clearly distinguish between local, regional and interregional travels given that the prerequisites and needs of the travellers are different in the three cases. Moreover, as pointed out by the authors, the two most important factors modifying the user preferences between local, regional and interregional solutions are related to the trip length or travel time.

The paper by Grison et al. [9] presents the results of a study to better understand the effect of contextual and individual factors on public transport route choices. To this end, a new method was developed based on the classical choice paradigm and recent findings in psychology.
The literature review depicts an overview of the different *attributes* (defined as characteristics of the route) and *criteria* (defined as user preferences) considered in previous works as well as the influence of contextual and individual factors in public transport route choice.
The *attributes* have been clustered into three groups:

- *instrumental* (e.g. travel time or cost),
- *symbolic* (e.g. norms, social representation),
- *affective* (e.g. emotional dimension linked to the travel/mode).

The authors claim that instrumental and affective factors are the ones researched with the highest frequency (instrumental factors are by far the most common ones) in the literature about public transport choice routes.
Regarding the criteria, the authors declare that they can also be clustered into three groups:

- *structural* (e.g. need for mobility),
- *individual* (e.g. socio-demographic, attitude towards transport modes or ecology, and habits),
- *contextual* (e.g. weather, time of day, emotional state when taking a decision, satisfaction with previous experiences in the same route).

The results of the empirical research performed by the authors show that the comfort of the route is preferred to the number of transport modes, especially for long trips; the choice of the comfortable alternative, or the one with only one transport mode, depends on user characteristics; the length of the trip and habits are the most important variables in the decision, but attitude also seems to play a major role.

The work by Erika Ramos et.al. [11] offers specific insights on user preferences for car sharing. Ride-sharing and ride-pooling are relatively new mobility options, therefore there is still a research gap in examining the travellers' perception of offered services characteristics. The study investigates the human factors of ride-pooling services. A Discrete Choice Experiment (N = 410) was performed to identify travellers' preferences concerning ride-pooling's service features. The study focussed on the effect of trip purpose on the appraisal of the service attributes, using six attributes:

- fare,
- walking distance to the pick-up point,
- time of booking in advance,

- shift of departure time,
- travel time, and
- information.

The results underlined that all of the six attributes significantly affected choice behaviour. The appraisal of the service characteristics differed depending on the trip purpose. The model revealed that low fares, a small shift of departure and information availability played a major role in user acceptance and the perceived utility of ride-pooling services.

5.2.1. The SMaRTE project

The SMaRTE project, presented in Section 5.1.1, can offer insights also on User Preferences. One of the activities carried out, analysed through a survey which are the important factors considered by users when travelling. Results can be useful to understand what are the preferences that a user may want to specify when looking for travel solutions.
The main result is related to a shift in the use of time in mobility towards the concept of "multitasking travel time". The importance of speed as a travel choice factor decreased, while the offering of high-quality and comfortable travel services is now a priority. To work and to be able to surf the web during the trip is a constantly increasing need, paired with a higher level of comfort during the trip (comfortable couches and seats, climatisation, plugs and connections, etc.). Pre and after-travel services that enhance the reliability of the travel experience are also increasingly important. Flexible ticketing and purchasing, easy booking process, after-sale services such as easy ways for compensation and reimbursement in case of service disruptions are becoming a must (and ICT tools facilitate it).
Moreover, users' preference for the car over public transport is highly influenced by three factors: door-to-door transport availability, flexibility and reliability.
Last but not least, social inclusion and accessibility (particularly in the case of disabled and elderly people) are also aspects affecting the choice of transport mode.

5.2.2. The BONVOYAGE project

The BONVOYAGE project, introduced in Section 5.1.1, promotes an innovative platform, able to elaborate discovery and linking services, and take the move from these services to structure advanced multi-modal trip planners, taking into account the EU framework of the cross-border ITS services recommended by Directive 2010/40/EU, in particular the Delegated Act for the provision of EU-wide multimodal travel information services (1926/2017).

From a technical point of view, The BONVOYAGE project has designed, developed and piloted a platform for customized door-to-door multimodal trip planning that integrates sources of non-real-time and real-time travel information, mono-modal or multimodal routing services provided by different stakeholders, eco-friendly loyalty programmes, multipart tariff schemes and machine-learning user profiling based on user needs and behaviours (e.g., from wearable devices).

The deliverables [3][4] of the BONVOYAGE project offer a wide analysis related to user profiling and user preferences, both from the state-of-the-art and from the results of the

Contract No. 881825

project activities. Moreover, the project explored personalization techniques based on user profiling through direct feedback and the usage of sensors monitoring travellers (e.g., stress level during a trip).
In the context of the project, a User Profile object has been designed to contain all the user-related information: personal information (e.g. age, gender, etc.), preferences (e.g. class category, best price choice), historical data (stress level, adopted transport modes, selected travel solutions, etc.), statistics (number of visits, number of purchased tickets, number of feedbacks, etc.), information related to his/her membership (collected points, membership configuration, etc.), and his/her achievements (in terms of calories, emissions or money, which allows the user to accumulate points from achieved targets).
When searching for a travel solution, the BONVOYAGE platform lets the user specify the following set of filters: price (price ranges, e.g.: 0-100 €, 100-200€, etc.), class category (first class, second class, etc.), hour range for departure and return trip (e.g. only morning, only evening, from hour XX to hour XX), total journey duration, comfort, environmental impact/footprint (e.g. CO_2 grams), total travel time, in-vehicles time, the number of changes, offers, meals, feedback score, services (Wi-Fi, non-smoker, gym, animals allowed), special needs. Considering special needs, the user shall specify if they relate to disabled people, a user with a baby chair, bikes to carry during the trip, pets to carry during the trip, luxury (this can also be a preference, but in this case, is treated as a need e.g.: limo and luxury for the honeymoon).

The personalization activity is then performed taking into account several aspects related to the user and not only the specific request. This type of information is both explicitly indicated by the user or inferred through different algorithms. Considering the first category of information, the user can specify:

- a set of *user categories* (zero, one or more than one): Bike lovers, Heavy Vehicles drivers (including both truck drivers as well as bus drivers), Luxury (5-star tourists looking for luxury travel conditions), Backpacker (hostel tourists), Low cost, Families, Business, Schools (students groups), Eco-friendly (CO_2 saving and naturalistic itineraries), Groups (tourists groups), Religious groups (religious tourism), Romantic (romantic travels for couples, scenic tours), Single, Adventure (adventure travels), Disabled travellers (with disabilities - also specifying the kind of disability), Food (wine and food travels), Art and culture (artistic itineraries), Music (itineraries for music events), Sport (itineraries for sporting events), Pregnant, Elderly, Daytripper (one day round trip), Special needs.
- a *list of constraints*, such as: selection of routes to be avoided (e.g. toll roads, highways), selection of vehicles owned (car, motorcycle, bicycle, etc.), selection of access to transportation (car sharing, bike sharing, cars, motorcycles, bicycles, etc.), and
- list of *user commitments*, such as: existing routes (accepted from an earlier query), tickets already reserved/bought and if they are refundable, progress (current position in route).

On the other hand, taking into account inferred information, the BONVOYAGE platform considered the following set of features:

Contract No. 881825

- *Number of transit nodes*: This feature allows to learn the number of transport modalities that user is willing to change during each journey (e.g., 1, 2, 3, etc.).
- *Used transport means*: This feature allows learning the most used transport means during the overall user's history (e.g., Car, Metro, Bike, etc.)
- *Private service cars*: This feature allows learning the most preferred private service car (e.g., Taxi, Car sharing, Carpooling).
- *Preferred class category*: This feature allows learning the most preferred class category for each travel (e.g., First class, Second class).
- *Total travel time global travel*: This feature describes the total travel time most used by each user for a journey in the European area.
- *Special request*: This feature allows learning the most requested ancillary service for each user in his/her journey history (e.g., Wi-Fi connection, Pet allowed, Smoker, etc.).
- *Walking distance during travel*: This feature allows learning the preferred maximum distance that each user is available to make.
- *C02 emissions*: This feature describes the sensibility of each user to the C02 emission, basically if each user is careful to choose travel solutions taking into account the C02 emission.
- *Comfort level*: This feature allows learning the most preferred comfort level of each user during each journey.
- *Range hour travel*: This feature allows learning the most preferred departure time.
- *Range price travel*: This feature allows learning the willingness to pay for each travel.

A latest useful insight from the BONVOYAGE project concerns the possible relation between Offer Categories and User Preferences. Indeed, once categorized a list of Offer considering different Categories, it is important to keep a model representing preferences of each user concerning the different Categories available. This is important to rank offers with different categories and offers an additional set of features for personalization algorithms.

5.2.3. The My-TRAC project

The My-TRAC[4] project is a Horizon 2020 project financed by the Shift2Rail initiative. My-TRAC aims to deliver an innovative application for seamless transport and an ecosystem of models and algorithms for Public Transport – PT user choice simulation, data analytics and affective computing. The principal objective of My-TRAC is to develop a novel transport-services platform designed for users as well as public and private transport operators. This improves the passenger experience by developing and applying advanced behavioural transport analytics and artificial intelligence (AI) algorithms. It develops a smartphone

[4] http://www.my-trac.eu/

application to connect information from public transport operators, MaaS providers and datasets related to the service and journey.

The paper in [17], written from partners involved in the My-TRAC project, provides valuable information that can be used concerning the conceptualization of user preferences. Distinct travel mode and departure time choice models have been developed for the Netherlands and Greece, and the variables that were found to have a statistically significant effect on the choices are presented.

Considering The Netherlands:

- *Travel Mode Choice*: Trip purpose, Travel time, Level of comfort, Travel cost, Number of trips performed by public transport/week, Number of trips performed by car/week, Age, Occupation.
- *Departure Time Choice*: Total travel time, Walking time, Fare discount, Frequency of travel mode, Importance of arriving on time when travelling for work, Gender, Trip purpose.

Considering *Greece*

- *Travel Mode Choice*: Number of trips performed by PT/week, Number of trips performed by car/week, Age, Occupation, Gender, Travel time, Level of comfort.
- *Departure Time Choice*: Total travel time, Walking time, Frequency of travel mode, Trip purpose, Importance of arriving on time when travelling for work, Age, Income, Household, Number of trips by public transport/week, Gender.

The work carried out in the My-TRAC project offers also other useful insights on aspects that can be taken into account when considering user preferences.

One interesting task carried out during the project tries to couple personality types and travel preferences. The methodology used, based on the Big Five model [8], summarizes the personality into five traits: Open-mindedness, Consciousness, Extraversion, Agreeableness, Negative emotionality (neuroticism).

Data about personality traits is gathered from the user when registering, using 15 short questions (e.g. I am someone who… tends to be quiet, tends to be disorganized, worries a lot, etc.). Each personality trait is associated to 3 of the 15 questions, each question's answers are bound to a 1 to 5 Likert scale (1 = strongly disagree, 5 = strongly agree) that allows computing an average score for each personality trait. Using this information, four clusters are identified: Well-adjusted resilients, Undercontrollers, Overcontrollers, Assertive resilients.

In the context of Ride2Rail, this activity may lead to identify user preferences considering factors such as risk-taking behaviour for ride-matching with unrelated people, user's comfort level considering the number of car occupants, the maximum admissible waiting time for riders out-of-vehicle (also concerning weather conditions), the maximum admissible delay (detour time) for drivers, etc.

Another interesting model developed within the My-TRAC project tries to predict users' next activity based on the user's activity profile. This can be useful to provide travellers some personal recommendations for places of interest based on the predicted type of user's anticipated activity. To do so, the accurate knowledge of the user's status (include prior activities, etc.) and demographic characteristics are essential. User's prior activities are also

fetched from social media, from where the text posted by users is retrieved and any activity included is recognized and stored in the user's activity profile. Specifically, the demographic characteristics of a user, such as age, gender, occupation and marital status, help the system provide these predictions. Additionally, their prior activities, during a certain period in the past, can help to infer the activity profile and subsequently compose a model about their potential next activity. The methods used are: Long Short-Term Memory network (LSTM), which is a type of Recursive Neural Network (RNN), for the activity prediction mechanism and, Natural Language Processing (NLP) techniques and classification methods, for the recognition of the user's activity from social media.

5.2.4. The SocialCar Project

The SocialCar[5] project is a Horizon 2020 project focusing on carpooling and investigating the possibility of incorporating it into existing mobility systems. In *SocialCar*, besides the classic contextual information needed to set a multimodal trip (departure, destination, current location, current time, and departure time), the user can express specific travel preferences, such as:

- maximum number of transfers (user-specified),
- maximum cost, in Euro (user-specified),
- maximum walk distance, in meters (user-specified),
- GPS Tracking (Yes/No),
- travel Modes (Bus/Carpooling/Feet/Metro/Rail/Tram),
- optimize travel solutions by (Cheapest/Comfort/Fastest/Safest/Shortest),
- carpooler Gender (Male/Female),
- carpooler Age Range (18-30/30-40/40-50/50-60),
- impaired (Visual/Hearing Impaired/Elderly/Wheelchair user),
- smoking (Yes/No),
- food (Yes/No),
- music (Yes/No),
- pets (Yes/No).

5.2.5. The EuTravel Project

The EuTravel project[6] coined the term of Optimodality, referring to the integration of multiple means of travel information, such as availability and fares, to extract optimised results for a travel query from point A to point B. Itineraries of several modes of transport and operators are constructed and presented to the travel planner user according to his/her predefined preferences, considering environmental sustainability of different solutions. Moreover, booking and managing of all the trip legs are implemented through a single

[5] http://socialcar-project.eu/
[6] https://www.eutravelproject.eu/

application. In case no preferences are set, the travel options presented are 'neutral', meaning that they do not penalise or ignore some options in favour of others (neutral display).

Regarding preferences, the traveller was given the option to pre-define some parameters, filters and ordering options to get personalised results, as listed below:

- *Travel duration*: Ordering options based on the total duration time of the trip (shortest, longest)
- *Price*: Ordering options based on the price (lowest, highest).
- *Distance*: Ordering options based on the total distance of means of transport that are used for the entire trip (shortest, longest).
- *Special Assistance*: Defining the kind of assistance needed during the trip covering (pregnancy, blind, deaf, and wheelchair).
- *Carbon emission*: If the traveller enables the carbon emission option, then the travel planner returns solutions with the lowest carbon emissions.
- *Max Displayed Solutions*: Defining the number of maximum returned solutions (alternative combinations) to be displayed.

In addition, the traveller was given the capability to define the *Minimum connection/waiting time between legs*. The default values were the following:

- Between two flights: 2 hours.
- Between a flight and a train: 1 hour.
- Between a flight and a ferry: 2 hours.
- Between a flight and a bus: 1 hour.
- Between two trains: 1 hour.
- Between two ferries: 2 hours.
- Between two buses: 1 hour.

5.3. Incentives

The analysis of the incentives focuses on a set of proposed frameworks, methodologies and reported experiences aiming at influencing users' choices. In the state of the art, several conceptualizations of the term Incentive, in different research areas, are available. To provide a complete overview, an analysis of several contributions considering different approaches is proposed:

- Section 5.3.1 analyses the theories on Behavioural Change, reporting interesting conceptual frameworks and experiences to understand key aspects in influencing people's behaviour,
- Section 5.3.2 analyzes the key role of motivation and the dichotomy between intrinsic and extrinsic motivations,
- Section 5.3.3 offers an overview of the state-of-the-art in non-financial incentives,
- Section 5.3.4 investigates the incentives tailored for the specific user,
- Section 5.3.5 introduces gamification as a powerful mechanism to obtain desired behaviours,
- Section 5.3.6 concludes the analysis reporting insights and experiences on incentives applied in the context of shared travel solutions.

Contract No. 881825

In this deliverable, the contributions analysed support the first conceptualization of incentives in Ride2Rail (Section 7.1.3) and are used to provide recommendations on incentives considering multi-modal travel offers (Section 7.5).

5.3.1. Behavioural Change

The report *"Behavior Change Tactics for Urban Challenges"* [21] focuses on a set of case studies reporting lessons learned and insights on behavioural change strategies applied to urban/social challenges.
The different use cases are categorized using relevant frameworks in the context of Behavioral Economics, a research area at the intersection of behavioural sciences (e.g., psychology and sociology) and human decision-making behind an economic outcome. The main assumption is that decision-making behaviour can be irrational and influenced by a specific context; for this reason, behavioural economists try to point out cognitive biases and factors influencing it.
A first successful attempt to frame the problem is provided by the MINDSPACE framework highlighting nine different aspects: Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitments, Ego. The same concepts and ideas were later refined and used to define a simpler framework, EAST, that, despite not being complete and detailed, can simplify the adoption. The EAST framework is based on four principal strategies to change behaviour:

- Make it **Easy**: use default options to encourage a given choice, reduce the effort required to increase uptake, simplify complex messages providing easier communications and simple tasks.
- Make it **Attractive**: attract attention, use rewards (also lotteries) to encourage a given behaviour and/or sanctions to discourage others.
- Make it **Social**: encourage showing other people behaving as desired, use the power of peer-to-peer connections and social relationships to spread and to support behaviours, promote commitments to others as a further incentive.
- Make it **Timely**: understand what is the best moment/situation to propose an action towards a given behaviour change, consider immediate costs and benefits more than those delivered later, help people in planning required steps to overcome barriers to action.

Using the abovementioned frameworks, twelve use cases are analyzed in the report. The results indicate that there is no "one size fits all" solution to the problem since there cannot be certain insights ensuring behavioural shifts.
In conclusion, three additional pieces of advice are formulated by the authors: relationships and the messengers are key aspects in advancing change, multiple different tactics should be put in place in parallel, the target audience should be understood and engaged intimately.

The report *"New Roads to Sustainable Travel*" [25] reviews some theories on behavioural change and explores their impact considering specific examples from the field of transport. The main approaches analysed in this report regarding the behaviour change are:

- *Rational Choice theory*: a classical approach that assumes a maximation of the subjective user utility.
- *Impact of environmental concern*: this approach has a strong focus on how the environmental factors impact the decision and under which circumstances. The "Low-cost hypothesis" (the likelihood of making a certain decision depends more on its costs than on its benefits) is one of the most important predictive tools of the behaviour regarding environmental considerations.
- *Framing*: defined as a set of concepts and perspectives through which the everyday experience is ordered and interpreted. It explains how certain phenomena are interpreted and why some elements of reality are not considered.
- *Theory of planned behaviour:* this approach states that humans are mainly guided by intentions or plans. People acting on their plan depend on three key factors: attitude (e.g. do I see any advantage in using a ride-sharing service?), subjective norms (e.g. would friends approve the use of ride-sharing services?), and perceived behavioural control (e.g. will I be able to use the app for multimodal travels without mistakes?). Each of these three factors influences the others.
- *Nudging*: this approach describes the use of small and indirect interventions to influence behaviour without changing people's attitudes or intentions. A typical example of this approach is the use of "defaults." An example of that would consist of defining the default search settings of a trip planner app by allocating a higher preference to a specific mean of transport. This practice, however, may raise ethical concerns.

A comprehensive model that includes elements from the approaches above, called the Behavioural Change Wheel, has been developed and used for explaining travel behaviour. According to this model, new behaviours arise from three sources:

- *Capability*: to change the behaviour it is necessary to know how or learn how to do so in terms of physical and psychological capabilities, skills and knowledge.
- *Motivation*: new behaviour requires motivation in terms of setting goals, making decisions and enjoying the desired behaviour.
- *Opportunity*: behaviour change needs an enabling and supportive environment, inducing the desired behaviour.

The report includes as well some examples of communication campaigns from the transport field that have been carried out in the last years, which have been based on one or several of the approaches previously presented.

5.3.2. Motivation

The paper from Ryan et Deci [27] focuses on the duality between intrinsic and extrinsic motivations and tries to overcome classic definitions. The basic distinction refers to intrinsic motivation when something is done because it is inherently interesting or enjoyable, and refers to extrinsic motivation when something is done for a separable outcome. While, usually, intrinsic motivation leads to greater engagement and better results, it is important to understand how to exploit extrinsic motivation to incentivize people doing tasks not inherently interesting or enjoyable. A taxonomy detailing the different types of extrinsic motivation is offered to better understand the important factors determining it that can lead

Contract No. 881825

to a process of internalization for personal commitment. Going from external to internal, the taxonomy identifies: External Regulation referring to punishment/rewards as motivators, Introjection involving ego and approval from others, Identification valuing the activity and self-endorsing goals, Integration representing full assimilation. A set of advices towards extrinsically motivated behaviours is provided. In particular, to increase self-determination, it is important to build social contextual conditions that support one's feeling of competence, autonomy and relatedness.

In [10] Deci provides further insights linking motivation and self-determination. Autonomous motivation, which is the basis for self-determination in human behaviour, consists of intrinsic motivation and integrated extrinsic motivation (i.e. doing an activity because it has become personally important for the person's self-selected values and goals). The two types are not always additive: intrinsic motivation is not always enhanced by increasing the extrinsic motivator and the same holds for the opposite. For example, it is reported that monetary and tangible rewards, deadline, threats of punishment, competition against others, directives and evaluations, negative feedback and controlling interpersonal climates are external motivators decreasing people's intrinsic motivation. On the other hand, choice, encouragement for self-initiation, acknowledgement, positive feedback, autonomy-supportive interpersonal climates are external motivators positively influencing one's intrinsic motivation.

5.3.3. Non-financial Incentives

The document by Gal-Tzur and Barsky in [2] describes the first attempt, in the Tel Aviv-Yafo municipality, to use non-financial incentives to promote the use of sustainable transport modes. In particular, the project exploited: *(i)* AlterNative by ZenCity, an application for trip planning based on environmental (CO_2 emissions) and health (calories consumption) criteria, together with the usual ones (time, cost), and *(ii)* social networks (Facebook) as a means to create a community among participants and to engage them towards more sustainable choices.

The main lessons learned are the importance of targeting people with an attitude towards environmental issues, at least in the first phase to start building an active community, the importance of cooperating with existing social networks (e.g. associations, organisations, etc.) and the possibility of initiating competitions or using fun activities/contents to engage the users. Moreover, the authors describe the value of an application with effective user experience and suggest the analysis of GPS movements to identify users' patterns and preferences (e.g., a favourable combination of transport modes or maximum acceptable walking distance) in order to offer more tailored suggestions.

The document also contains a deep literature review with interesting references. The authors cite several works on behavioural economics suggesting the importance of "loss aversion" (or gain-loss asymmetry), i.e., the fact that people are more influenced by negative impacts, or losses, rather than by positive impacts, or gain. This insight suggests the usage of negatively framed information, i.e. highlighting bad aspects of a given behaviour, instead of

Contract No. 881825

emphasizing positive aspects of desired behaviour. The work from Schultz et al. [29] suggests how to use emoticons as injunctive norms.
Another important aspect highlighted is that people like to enhance their self-image doing good and want others to see that they are behaving prosocially. In this context, extrinsic incentives like monetary ones, have the effect of reducing the value of voluntary acts in the eyes of others and can have opposite results.

The deliverable [3] published within the BONVOYAGE project offers a deep analysis of non-financial incentive schemas in the state-of-the-art. In particular, the analysis considers current tariff models, initiatives and policies to promote sustainable mobility and reduce the impact on the environment. As a main result, it shows that CO2 emissions are the core variable for assigning scores and achievement of awards to the users.
The main common and relevant features identified in different programs and initiatives analyzed are:

- Provision of information about the level of CO_2 emissions for each travel itinerary.
- Provision of credits/points based on the users means of transport choices, promoting the use of means of transport with a low level of CO_2 emissions. These points can be used by the users to obtain prizes, awards and discounts (e.g., WeCity[7]; TraffiCO2[8]; UbiGo[9]).
- Monitoring functionality, where users' mobility behaviour is tracked to provide feedback and alternatives to reduce private motorized transport usage and increase the use of public transportation and vehicle sharing (e.g., GoEco[10]; Tripzoom[11]).
- Provision of personal incentives based on the users' behaviour (e.g., Tripzoom).
- Possibility to purchase and obtain a package of travels with different means of transport (e.g., through a monthly pre-paid subscription) at a lower price for environmentally sustainable alternatives
- Creation of a "gamified environment" (e.g., offering the possibility to invite friends to save CO_2, to create games and to share achieved results and information with other users), leveraging on people motivation and ambition to achieve their personal goals is another opportunity.

As suggested by the authors in the deliverable, people ambition seems to be an important lever to influence their behaviour. Defining personal challenges, individual objectives and personalized incentives in terms of reduced environmental impact can be an effective mean to change people's behaviour.
As a result of this analysis, a Score Policy to promote eco-friendly behaviours has been designed. This policy exploits a set of rules to attribute a variable score to the travel solutions proposed to the BONVOYAGE's users. Based on these systems, the user gains a certain

[7] WeCity https://www.wecity.it/en/
[8] TraffiCO2 http://www.traffico2.com/en/
[9] UbiGo https://www.ubigo.me/
[10] GoEco https://www.goeco.org/
[11] Tripzoom http://en.tripzoom.nl/

amount of points (i.e. Ecopoints) per each travel selected, which are then summed to the scores gained over previous selections. These points are used to update the Overall Score for a user and to define its profile using four levels from Eco-friendly to Not-Eco-Friendly. As reported in [5], the Score Policy has been tested by designing an ad hoc procedure aimed at verifying the effectiveness and impact of the mechanism on a heterogeneous sample of users.
The test procedure has been structured considering the peculiarities of the implementation of the "Urban Soloist model", namely the provision of integrated planning services concerning multimodality real-time information and car-pooling services in a limited urban area. To isolate and assess the impact of the score policy on users behaviour, the test procedure makes use of two different versions of the BONVOYAGE interface. This test compares the choices made by the sample exposed to the score policy to the results gathered by a sample of users that are not aware of the existence of the Score Policy mechanism.
Indeed, the first version of the testing interface does not express the value of the earned score (attributed according to the BONVOYAGE Score policy), so that the tester has no incentives to modify the travel choices towards an eco-friendly behaviour. The second testing interface embeds the score policy and explicitly reports the score gained by the tester, updating the profile of the user at the end of each period considered. This version enables the "End-user" to better understand the consequences of travel choices, promoting eco-friendly choices.

A similar approach is currently applied by Trenitalia, recognizing their contribution to the environment by providing Green Points to the passengers for each ticket purchased to travel on FRECCE and Intercity being part of the CartaFRECCIA loyalty programs, in addition to the normal Loyalty Points. These are additional loyalty points, assigned by Trenitalia to the customers based on the KM travelled by train, as a reward for choosing the train instead of the car and the plane. Practically, CO_2 savings turn into points.
These extra points awarded thanks to the saved CO_2, are assigned to the passengers in relation to the commercial km travelled (1 point every 10 km) on FRECCE and Intercity and will be added to those earned in the other ways provided by other Trenitalia Loyalty Programs. Green points are not able to ensure the achievement of the next status. The points will also be recognized in the case of season tickets, as a lump sum, as follow:

- 6-day subscription: the commercial km travelled multiplied by 3;
- weekly subscription: the commercial km travelled multiplied by 3;
- fortnightly subscription: the commercial km travelled multiplied by 5;
- monthly subscription: the commercial km travelled multiplied by 10;
- quarterly subscription: the commercial km travelled multiplied by 30;
- six-monthly subscription: the commercial km travelled multiplied by 60;
- 9-month season tickets: the commercial km travelled multiplied by 90;
- annual subscription: the commercial km travelled multiplied by 120;
- 10 travel booklet, the commercial km travelled multiplied by 10.

5.3.4. Personalized Incentives

Contract No. 881825

Personalized Incentives refers to a category of incentives tailored to the specific target user and are usually customized by combining information from the set of user preferences and the user history.

An interesting example of personalized incentives is provided by Trenitalia suggesting the importance of providing personal incentives based on users' behaviour. Trenitalia currently employs a Multichannel Precision Marketing system based on an up and running CRM able to categorize eleven use cases of "loyalty", "cross-selling" and "upselling" to specifically influence the user behaviour. From the first application to the Trenitalia B2C Website, Precision Marketing is now enabled on other main sales digital channels, as Trenitalia Mobile App and Trenitalia Mobile Site. Examples of employed strategies are listed below.

- **Recurrent customers**: The recurrent purchase of a specific ride journey may determine the offering of a tickets carnet with advantageous economic conditions.
- **Purchase recurrent reduction**: The reduction in the recurrence of purchase by a customer can determine the proposal Discount Coupons / Access to FRECCIAClub, in order to encourage future purchases.
- **Average expense reduction**: The reduction of the Average Spending of a Customer can determine the offer of Discount Coupons for the purchase of a Business Class in order to restore the Spending level.
- **Service Upgrade**: The recurrent purchase of travel tickets in the same class can determine the proposal, at the same price, of a higher class ticket aiming at stimulating the customer to try the service upgrade.
- **Dedicated Offering "Still Young"**: The analysis of the characteristics of the customers allows to identify and design targeted offers in order to stimulate the ticket purchase by specific classes of passengers.
- **Travel during the week or the weekend**: recurring purchase of mid-week or weekend FRECCIA travel tickets can imply the proposal of a Discount Coupon for the alternative period.

Delgado and Davidson in [7] analyse recommendations mechanisms for the travel and hospitality industries. In this context, to have a successful recommender system, they emphasize the need of providing original and customized content for the traveller, rather than hoping he/she will find out what he/she needs. Motivated by this and considering incentive mechanisms, it might be useful to employ two strategies: *(i)* enriching the system thanks to content providers who provide genuine content regarding different topics such as locations, TSPs, and so on, and *(ii)* tailoring the messages from TC (like promotions, notifications,...) to the user in such a way that he/she feels that these messages are personalized for him/her.

5.3.5. Gamification

Gamification is the craft of deriving all the fun and engaging elements found in games and applying them to real-world or productive activities. In the work from Chou in [34], a Gamification framework, called *Octalysis*, has been defined to analyze and build strategies

to make a game/activity fun. According to this framework, every activity a person does is based on one or more of the following eight core drivers:

- Epic Meaning & Calling: the person believes that she is doing something greater than herself or she was "chosen" to do something.
- Development & Accomplishment: the person acts to make progress, developing skills, and eventually overcoming challenges.
- Empowerment of Creativity & Feedback: the person is engaged in a creative process in which she needs ways to express her creativity and needs to be able to see the results of her creativity, receive feedback, and respond in turn.
- Ownership & Possession: the person is motivated because she feels like she owns something and, as a consequence, she innately wants to make what she owns better and to own even more.
- Social Influence & Relatedness: The person is driven by social elements such as mentorship, acceptance, social responses, companionship, as well as competition and envy.
- Scarcity & Impatience: the person acts because she wants something that she cannot have.
- Unpredictability & Curiosity: the person is driven by the desire to find out what will happen next.
- Loss & Avoidance: the person acts to avoid that something negative (e.g., losing previous work) happens.

The definition of incentives in Ride2Rail should take into account these core drivers, keeping in mind that a good incentive does not need to use all of the 8 core drives, but it needs to focus well with the ones it does implement. Some extremely successful products do very well with Social Influence, while others just utilize Scarcity.

After the definition of the core drivers to be used, Octalysis [34] suggests to decline the drivers in the different phases that characterize e.g., the launch of a new product: Discovery (why would people even want to try it?), Onboarding (how do you teach users how to use it?), Scaffolding (the regular usage towards a goal), Endgame (how to retain the usual users?).

The last suggested step consists of considering different player types, so to be aware of how different types of people are motivated at different stages of the experience. This appears to be fundamental also for Ride2Rail in order to efficiently engage a large number of users.

The paper from Opromolla et al. [1], suggests how game elements applied in different moments of the travel experience and disseminated in different elements of these hybrid spaces can enhance the interaction between people and mobility services. The analysis of the academic literature shows that the increase in engagement provided by said gamification elements, specifically in the mobility field, is above all directed to encouraging sustainable mobility. As also pointed out by E.L. Deci [10], when talking about motivation and engagement there is a lack of effectiveness of monetary incentives: these do not maintain long-term effects but they end when the reward ends. Also, while indicators such as distance, speed, and the saved CO_2 values are often used, they are considered too

abstract in the perception of travellers and are therefore not effective for motivating people in the long term.

According to Handy et al. [28], the effective gamification elements should refer to more concrete factors such as information about comfort, safety and environmental conditions, which are essential for those people who would like to adopt sustainable behaviours.
It is necessary to adopt a user-centred design approach, which can connect the gamified elements to the micro-activities that the travellers play in the different journey stages. To achieve the mentioned objectives, this paper proposes to emphasize the social interaction between users and their ability to share knowledge. All this must refer to the whole travel experience and be optimized for each stage, simplifying the most difficult activities and making them more pleasant.

5.3.6. Shared Travel Incentives

The report "*Human Factors in Exclusive and Shared Use in the UK Transport System*" in [12] highlights that travel choices do not conform to rational decision mechanisms. For this reason, incentives to encourage shared travel should not focus only on cost-benefit analyses. Moreover, users' choices are very little influenced by environmental motivations. On the other hand, the sociotechnical context has a great effect on travel choices that are dynamic, evolve with practice and are bound to physical, cognitive, organisational and social factors. In particular, the report highlights how relying on networks built through social networks is not enough to incentivise sharing and how the physical organisation (e.g. shared travel organized with people working together) is more effective.
The integration of shared travel with public transportation is presented as a key enabler to incentivize sharing, also supported by the advent of MaaS platforms. A feasible approach is to present shared travels as an occasional alternative to the private car or the public transport solution. Once a user collects several ride-sharing experiences, other factors can be effective in changing his/her habits.
The report suggests also focusing on the overcrowding/disruption of public transport as an incentive for sharing schemes. One-time events (e.g. strikes) should be exploited since they encourage the adoption of an occasional ride-share solution. Moreover, if the user experiments overcrowding/disruption frequently while using public transport, the possibility and the experimentation of an alternative can help in increasing long-term adoption of shared travel.

The study "*Ridesharing as a Complement to Transit*" in [23], provides a long list of incentive mechanisms adopted by transit agencies to incentivize ridesharing in users. Of the 13 transit agencies considered, more than half affirmed that they use prizes such as gift cards to encourage ridesharing. Nearly 40% use recognition in print or web publications. Direct cash subsidies, loyalty programs, commuter checks (vouchers used for multiple transit providers and vanpool services) and transit vouchers are offered by almost one-third of respondents. Nearly 10% offer HOV (High Occupancy Vehicle) parking or parking discounts. Those who responded "Other" also listed annual lunches, HOV lane access, and incentives funded by private sponsors.

The report by Whillans and Kristal in [33], highlights that American employees spend, on average, 200 hours a year commuting to work, and 3/4 of these commuters drive to work alone. Commuting alone by car is not just bad for the environment (24% of global energy-related CO_2 emissions come from transportation), it is also bad for business. Car commuters report higher levels of stress and lower job satisfaction compared to train commuters — in large part because car commuting can involve driving in traffic and navigating tense road situations. A study, described in [33], has been conducted with a company that employs more than 70.000 people to understand how to change employees' commuting behaviour from driving alone to more active modes like carpooling, taking public transit, biking, or walking.

After surveys and interviews with employees, a series of experiments have been conducted:

- A matchmaking service was offered to 15.000 employees to enable carpooling. A priority parking and a free 24/7 emergency ride-home service were offered as incentives. Result: only 100 employees signed up to the carpooling service, and only 3 were using it a month later.
- One week free bus ticket was offered to 7.500 employees to try to increase the purchase of discounted public transport passes. Result: only a marginal effect on the use of public transportation.
- A personalized travel plan was offered to 1.000 employees, showing how they could commute to work to save both time and money. Result: no effect also in this case.

The analysis reports that these nudges weren't effective for three reasons. First, employees didn't have to bear the full financial cost of car commuting, since the organization offered their employees free parking spaces, and they were not paying for the environmental costs of driving. Second, taking transit or carpooling can benefit society, but it is often less convenient for an individual commuter. People can be slow to take up more sustainable commutes because of the time it takes to plan public transit and carpool, at least in the beginning. Third, these approaches required changing habitual behaviour, which is notoriously difficult to change.

To shift habitual commuting behaviour, the following options are suggested and should be considered by Ride2Rail:

- *Make the full cost of driving salient for employees*: avoid subsidizing parking or other infrastructure that masks the full cost of driving to work alone. This does not just mean taking away free parking; it could also involve giving employees the monetary equivalent of parking as a bonus, and then allowing employees to choose to use the bonus to pay for a parking spot or to keep the cash and choose alternative modes of travel.
- *Make driving harder, and make other forms of commuting easier*: by making driving and parking less convenient (e.g., cut the size of parking lots in half; provide remote parking lots for those who drive alone, compared with parking next to the front door for those who share rides), you can enhance the convenience, safety, comfort, and cost-savings of other modes like carpooling. More substantial cash and non-cash incentives could also be used to motivate riders to shift their commuting behaviour from driving alone to taking public transit.

Contract No. 881825

- *Change the default work arrangement*: it is possible to change the norm by only letting employees park at work three out of five days per week, and/or allowing them to work from home or work from anywhere, so they commute to the office less often.
- *Think about timing*: since people are more likely to change their commuting behaviour when they move or start a new job, or when there is a serious disruption that forces them to temporarily abandon their habits, these are the times when employers could try using behaviorally informed messaging and light-touch incentives.

The article from Monteiro et al. in [22], investigates a novel approach to boost ride-sharing opportunities based on the knowledge of the human activities behind individual mobility demands. They observe that, in many cases, the activity motivating the use of a private car (e.g., going to a shopping mall) can be performed in many different places. Therefore, when there is the possibility of sharing a ride, people having a pro-environment behaviour or interested in saving money can accept to fulfil their needs at an alternative destination. They thus propose activity-based ride-matching (ABRM), an algorithm aimed at matching ride requests with ride offers, possibly reaching alternative destinations where the intended activity can be performed. By analyzing two large mobility datasets extracted from a popular social network, they show that their approach could largely impact urban mobility by resulting in an increase up to 54.69% of ride-sharing opportunities with respect to a traditional destination-oriented approach.

In the context of the SocialCar[12] project, different incentives have been used to promote carpooling and as an effective way to increase membership and remove any preconceived barriers that the users may have. Some examples are:

- *Priority parking*: by proactively taking into account parking spaces at regions of high car pooling demand, SocialCar system can create an effective incentive. Priority parks are usually the parking spaces closest to these high demand regions or in the nearest parking building, and are a huge incentive where the parking supply is limited or where drivers have to walk long distances between the car park and their actual destination. Parking permits should be used to identify the priority spaces, which also helps to raise the visibility of SocialCar carpool scheme.
- *Financial incentives*: these can include cash rewards, prize drawings or rewards in the form of free or discounted parking fees. Financial rewards may also include free or discounted tickets for the SocialCar application. Setting up a carpool 'miles scheme' can also be effective, which awards participants with gift vouchers or discounts at local restaurants, or shops for the number of miles they travel in a carpool.
- *Point System*: SocialCar application adopts a Point System strategy letting users gain points that can be used to redeem one of the possible rewards. A user can earn points every time another user rates him/her and the number of points earned is proportional to the rating received (e.g., 5 stars equal to 5 points). At the end of

[12] http://socialcar-project.eu/

every week, a user can redeem their points to get a reward whose value depends on the total number of points available. If more than one reward is available, then the user can choose the desired one from a list of all the available rewards provided that his/her points are adequate.

5.4. Summary of State-of-the-art Contributions

Table 1 provides an overview of how the different literature works and projects analysed in this chapter contribute to the definition of *Offer Categories, User Preferences* and *Incentives.* Moreover, for each concept, we identified a set of recurrent patterns emerging from the state-of-the-art and to be taken into consideration for the Ride2Rail conceptualization. In the table, we cluster contributions as follows.

For *Offer Categories*, we consider the following patterns:

- Types: identification of *types of variables* describing a multi-modal travel offer.
- Variables: identification of *actual variables* describing a multi-modal travel offer that can be used to define offer categories.
- Factors: identification of multiple *determinant factors* enabling enhanced offer categorization.

For *User Preferences*, we consider the following patterns:

- Traveller: identification of *Traveller-related* User Preferences (e.g., socio-demographic aspects, psychological aspects, behavioural aspects, etc.).
- Service: identification of User Preferences on *Service-related* aspects (e.g type of seat, travel class, etc.).

For *Incentives*, we consider the following patterns:

- Beh. Change: identification of factors influencing *behavioural change* in users.
- Motivation: analysis of the role of *motivation* in incentivizing a given behaviour.
- Non-Financial: identification and analysis of *non-financial* incentives.
- Personalized: analysis of *personalized incentives* tailored to the specific user.
- Gamification: identification of *gamification* strategies as an incentive.
- Shared Travel: analysis of incentives for *shared travel* solutions.

In the table, literature works are reported in the order they are presented, projects are listed at the end in alphabetical order.

Work/Project	Offer Categories			User Preferences		Incentives					
	Types	Variables	Factors	Traveller	Service	Beh. Change	Motivation	Non-Financial	Personalized	Gamification	Shared Travel
Clauss and Döppe [30]	X	X									
Zhao J. [35]	X	X		X	X						
Golightly et al. [12]		X									X
Hansson et al. [13]		X	X		X						
Wei and Cornet [32]		X	X								
Gal-Tzur et al. [2]		X						X			
Lem A. [18]		X									
Neveu et al. [24]		X	X								
Lugano et al. [19]		X	X								
Ricci F. [26]				X	X						
Wang et al. [31]				X							
Grison et al. [9]				X	X						
Ramos et al. [11]					X						
Koliou et al. [17]					X						
Digman J. M. [8]				X							
Behavior Change Tactics for Urban Challenges [21]						X					
New Roads to Sustainable Travel [25]						X					
Ryan and Deci [27]							X				
Deci E. L. [10]							X				
Schultz et al. [29]								X			
Delgado et al. [7]									X		

Work/Project	Offer Categories			User Preferences		Incentives					
	Types	Variables	Factors	Traveller	Service	Beh. Change	Motivation	Non-Financial	Personalized	Gamification	Shared Travel
Chou Y. [34]										X	
Opromolla et al. [1]										X	
Handy et al. [28]										X	
Ridesharing as a Complement to Transit [23]											X
Whillans and Kristal [33]											X
Monteiro et al. [22]											X
BONVOYAGE project		X	X	X	X			X			
EuTravel project					X						
MoTiV project		X	X								
My-TRAC project				X	X						
SMaRTE project		X		X	X						
SocialCar project					X						X
Trenitalia Green Policy								X			
Trenitalia Precision Marketing									X		

Table 1 – Matrix summarizing the analysed contributions.

Contract No. 881825

6. IP4 TERMINOLOGY ALIGNMENT

The Ride2Rail project is strongly related to the Shift2Rail IP4 work programme and is complementary to the ongoing CFM projects CONNECTIVE, COHESIVE, and MaaSive. In particular, the conceptualization carried out in WP2 will contribute to TD4.1, complementing the work initiated by IT2Rail and under refinement in the SPRINT and CONNECTIVE projects. The conceptualization defined in Ride2Rail should be built on the state-of-the-art analysis reported in Chapter 5, but it should also be aligned with IP4 ongoing activities. This chapter reports on the outcomes of the activities carried out to align the conceptualization of Offer Categories, User Preferences and Incentives to the terminology currently used in the IP4 ecosystem. The described results have been achieved thanks to a set of collaboration meetings organized between Ride2Rail and representatives of Call-For-Members (CFM) IP4 projects.

The discussion on the relevant IP4 terminology has been started organizing a meeting (14th February, 2020) with Ride2Rail partners previously involved in IT2Rail. In Section 6.1, the IT2Rail concepts recognised as relevant for the conceptualization of choice criteria and incentives are described; in Section 6.2, the IT2Rail Preference model, recognised to be a solid basis for the Ride2Rail conceptualization of User Preferences, is detailed.

The results of the IT2Rail terminology alignment were successively compared with the more recent developments in IP4 terminology analysing deliverables received from CFM projects (i.e., CONNECTIVE and MaaSive). The outcomes of this activity were preliminarily discussed in the 1st Collaboration Meeting with IP4 CFM Projects (24th March, 2020) organized by the Ride2Rail consortium, and then, extensively analysed in an additional meeting (1st April, 2020) specifically focused on the terminology alignment. In Section 6.3, the final diagram describing the current IP4 terminology relevant to the Ride2Rail conceptualization of choice criteria and incentives is presented and discussed. Last but not least, in Section 6.4, the current list of implemented User Preferences received from the CFM projects is reported, providing the initial set of User Preferences to be considered.

6.1. IT2Rail Terminology Alignment

In this section, the relevant terminology identified in IT2Rail for the conceptualization of choice criteria and incentives is discussed. The presented terminology is extracted from IT2Rail deliverables [14][16] and described thanks to the collaboration of Ride2Rail partners previously involved in IT2Rail. As it would be clear, the current IP4 terminology that is relevant to the objectives of this deliverable relies on concepts inherited from IT2Rail. For this reason, a two-step alignment is proposed starting from IT2Rail.

The IT2Rail terminology covers different aspects of the technical framework, e.g., travel shopping, booking and ticketing, trip tracking, etc. A first significant result obtained in this preliminary analysis is to circumscribe the focus of the alignment to the *Travel Shopping* and *Travel Companion* ontologies, i.e., the models referring to the process of a user with a mobility need and looking for multi-modal travel offers (Travel Shopping) through its personal application (Travel Companion).

To identify the relevant terminology, a diagram (Figure 2) is proposed representing the main components involved in the *Travel Shopping* flow, and for each of them the set of

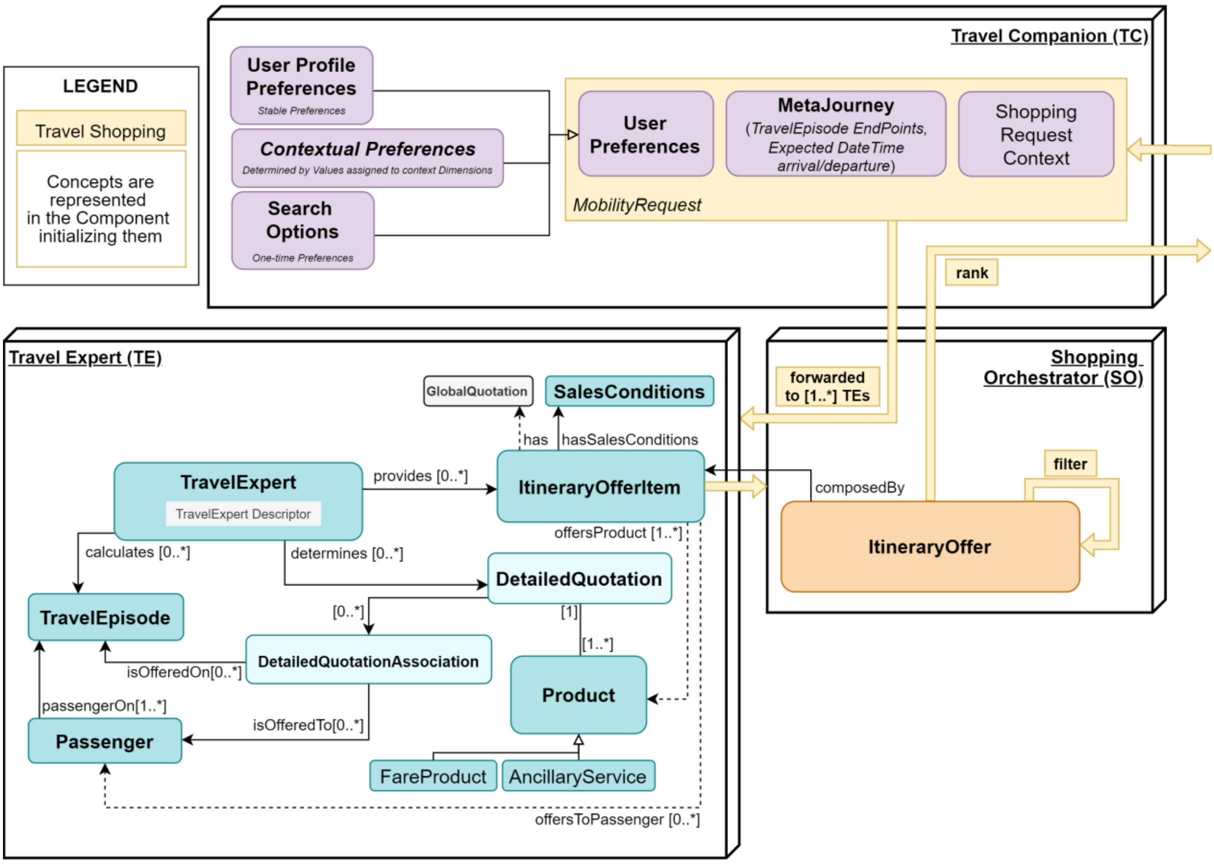


Figure 2 – IT2Rail Terminology alignment diagram

concepts and relations that are specifically instantiated or handled by that component. The presented diagram does not aim at providing a complete description of the IP4 architecture and focuses only on components introducing relevant concepts; indeed, components like the *Cloud Wallet*, storing user's data safely, and the *Interoperability Framework*, handling data heterogeneity, are omitted for simplicity. The flow of a generic *Travel Shopping* process is presented to describe the components, the concepts and the relations in the diagram.

The Travel Companion (TC) is the user's personal application and provides an interface between the user and the IP4 ecosystem. The TC allows a user to store and share his/her personal preferences, to access all travel services needed for the journey (shopping and booking), to store the rights to travel, and to receive notifications on his/her trips (trip tracking). The TC is more than a simple frontend; it aims at being a digital representation of a person.

In particular, to initialize a *Travel Shopping* interaction, the TC collects data needed from the user to generate a Mobility Request containing data on the *Shopping Request Context* (TC metadata), the *Meta Journey* (origin, destination, expected date-time departure/arrival) and the *User Preferences*.

User Preferences, explained in detail in Section 6.2, represent the user profile (stable preferences), the contextual preferences (preferences determined considering the current context), and the search options (one-time preferences) for the specific request.
The TC sends the generated Mobility Request to the Shopping Orchestrator (SO) that is responsible for handling the Mobility Request providing a set of offers satisfying it.

The SO receives the Mobility Request, and will then invoke multiple Travel Experts (TE) to obtain travel solutions. A TE can be managed by a TSP or an intermediary selling TSP solutions. In detail, the SO takes the Mobility Request, it analyzes the itinerary requested by the user and identifies the TE that can provide solutions on that itinerary. Moreover, since TEs have different capabilities, the SO analyzes the TEs Descriptors to determine which data, and in particular which *User Preferences*, can be understood by a given TE. In this way, the SO can avoid receiving travel solutions that should be discarded, and the TE prevents receiving User Preferences that it wouldn't be able to process.

A single TE may return zero, one or more ItineraryOfferItems in response to a given request from the SO. The main concepts defining an ItineraryOfferItem are the Travel Episodes (i.e., the trips on a single vehicle provided by a TSP and offered to cover the meta-journey), the Products (FareProduct, that identify the purchasable item offered by the TSP, or AncillaryServices that identify additional products, e.g., included meals) and the Passenger(s) involved (e.g., person, type/number of people, animal, bike). It is the relation between these three concepts that determine what the TE returns as an ItineraryOfferItem. In an ItineraryOfferItem there must be a Product, there may be Travel Episodes, there may be Passengers. For example, a pass or metro ride for the whole network (a FareProduct) may be offered without referring to a particular Travel Episode and to a specific Passenger (i.e., the "holder").
For a single Product in an ItineraryOfferItem, a TE may determine multiple DetailedQuotations referencing different combinations of Travel Episodes and Passengers in the ItineraryOfferItem. If a Travel Expert cannot provide DetailedQuotations, or if they are not applicable, then a GlobalQuotation is instantiated (at the ItineraryOfferItem level). An ItineraryOfferItem is also associated with a set of SalesConditions determined by the TE.
The TE also provides additional information not reported to avoid overcomplicating the diagram. For example, a TravelEpisode is characterized only by start and end endpoints (can also be a GPS coordinate), and does not have timing information. This information is related to the TransportationService concept identifying the operation of a given Travel Episode on a specific date/time.

Once received ItineraryOfferItems from the different TEs, the SO should understand how to combine them to compose a set of multi-modal trips. In the context of Ride2Rail, a Ride-Sharing TE should also be considered as a potential provider of ItineraryOfferItems.
The set of ItineraryOfferItems returned by TEs is processed by the SO to build a set of ItineraryOffer. In doing so, the SO filters out all the possible solutions that do not fulfill User Preferences in the received MobilityRequest.

Contract No. 881825

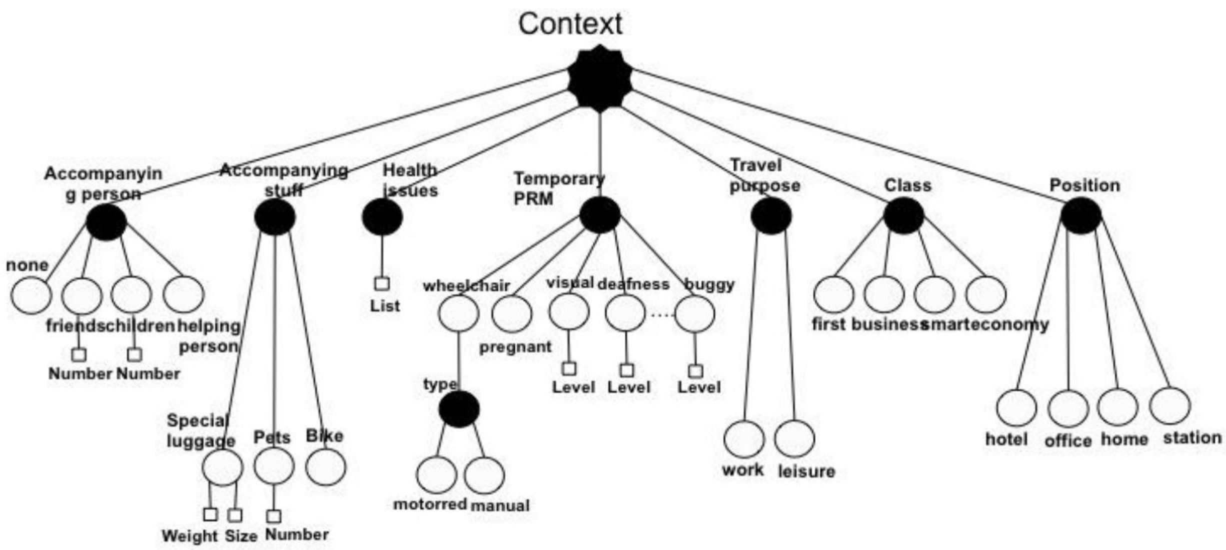
The TC receives as a response to the MobilityRequest a set of ItineraryOffers. The TC is responsible for ranking them accordingly to the User Preferences and displaying them to the user.

The identified terminology clarifies that with respect to the Ride2Rail objective of conceptualizing choice criteria and incentives, the IT2Rail ontologies include only the concept of User Preferences, that will be analysed in detail in the following section.

6.2. IT2Rail Preference Model

The relevant preferences for a user are influenced by the domain considered, in our case the transportation domain. Moreover, they may depend on two different aspects: the personal habits/tastes of the user and the environment, in other words, the current context.
In the Travel Companion (TC), a conceptual representation is needed to model preferences for a specific user. In particular, in the IT2Rail project, the objective was the design of a model of preferences that can be *context-aware*. The proposed model exploits the representation of the possible situations, i.e., contexts, in which the users might find themselves, and the specification of user preferences in that specific contexts.

A tree-based context model (*Context Dimension Tree, CDT in what follows*) has been proposed to describe contexts. An example of CDT describing the possible contexts in which the users of the IT2Rail platform can find themselves while buying tickets and travelling is shown in Figure 3. The CDT is a hierarchical representation using two kinds of nodes*: dimensions* nodes (black nodes) represent the different perspectives that can be used to describe the context, while *concepts* (white nodes) represent the admissible values



for each dimension.Figure 3 - Travel Companion Context CDT
Figure 3 - Travel Companion Context CDT

An example of a context, considering the CDT in Figure 3, is a person who is "travelling alone, in economy class, for leisure and carrying a bike with her". Of course, the context influences the travel choices of this person and possibly her preferences.

Three different types of preferences have been considered to define the IT2Rail preference model:

- The *Profile Connected Preferences* – this is a list of personal characteristics of a user. It can include some "stable" preferences, which are tailored by the permanent features of the customer, in the sense that they can be modified, but at a low rate (e.g., fidelity cards, vegetarian food, diabetic diet, if he/she is on a wheelchair, etc.);
- The *Contextual Preferences* – these preferences depend on the context in which the travel happens; therefore, they can be accounted for by the Travel Companion whenever a specific context is active;
- The *Search Options* – these preferences can be selected and specified by the user during journey planning (one-time preferences).

In the proposed model, each User Preference is associated with a numerical score in the interval [0, 1].

The value 1 represents a *mandatory requirement*, while the value 0 denotes a *mandatory exclusion* and they are both values that can be used to filter offers. The other scores in the interval can be used for ordering the different offers. Formally, it is possible to define the model using *sigma-preferences*, i.e., preferences on data items which fulfil a given selection condition expressed on the data item as a propositional formula. A sigma-preference is expressed as a triple *<userID, SQ, score>,* where the *userID* can be the ID of the specific TC, *SQ* (selection query) is the selection condition, and *score* is a real number in the interval [0; 1], e.g., *(<U1, class=Smart, 0.9>)*.

Sometimes the rank of an offer might be based on two different attributes, for instance, class and price. In this case, the rank will be computed by combining the preferences according to some formula that can be decided. Examples are linear combinations (normalized to the interval [0,1]), where a different weight is assigned to each preference score, or a simple average.

A contextual preference can be expressed as a quadruple: *<userID, context, SQ, score>*. Each user has a CDT describing his/her contextual preferences.

In the designed representation, each possible concept for a dimension in the CDT may have a set of contextual preferences associated with it. The activation of the given concept in the active context allows the system to assign the correct rank to the preferences.

To provide an example, let's consider the CDT in Figure 3. Assuming that a user U1 has the following preferences when is travelling for work (Travel purpose = Work) [*<U1, Travel purpose = Work, class = Business, 0.7>, <U1, Travel purpose = Work, class = First, 0.8>*], and that the same user U1 has the following preferences when is travelling accompanied by some friends (Accompanying person = Friends) [*<U1, Accompanying person = Friends, class = Business, 0.6>, < U1, Accompanying person = Friends, class = Economy, 0.6>, < U1, Accompanying person = Friends, class = Smart, 0.6>, < U1, Accompanying person = Friends, class = First, 0.1>*].

Given these assumptions and considering a context C1 where the user U1 is travelling for work but is accompanied by some friends, it is possible, for example, to consider the average

of the preferences and obtain the following ranking scores: [*<U1, C1, class=Business, 0.65>, < U1, C1, class=Economy, 0.6>,< U1, C1, class=Smart, 0.6>, < U1, C1, class=First, 0.45>*].

The list of preferences, profile and context data collected in IT2Rail and reported in the "*Annex 5: Preferences, Profile and Context Data as suggested by the WP Partners*" [15] represent a list of possible instances to be considered by Ride2Rail.

6.3. Current Terminology Alignment

In this section, starting from the presented alignment on the IT2Rail terminology, the latest developments in the IP4 terminology are presented.

As reported in the CONNECTIVE Deliverable on the A-Rel Architecture [6], the IP4 ontology is currently undergoing an in-depth process of modularization and extension considering already standardized formats (e.g., Transmodel, NeTEx, TRIAS, etc.). For this reason, it has been decided to avoid focusing on an extension of the current ontology and to work instead for a conceptualization of choice criteria and incentives to be integrated with the latest release of the MaaSive Glossary [20]. The MaaSive Glossary contains a description of the IP4 terminology and offers a comprehensive view of concepts and components. The relationships among the different concepts and components and their contextualization with respect to the *Travel Shopping* process were discussed in the meetings organized with CFM projects to obtain a final diagram supporting the Ride2Rail conceptualization (shown in Figure 4).

The main flow defined by IT2Rail is still valid in the current IP4 terminology and also the current IP4 *User Preferences* model is still influenced by the outcomes of IT2Rail (the *User Preferences* currently implemented in IP4 are presented in Section 6.4).

The main differences introduced in the terminology are due to the fact that different communication interfaces (e.g., TRIAS) are used by CFM projects, and the current terminology merges together different reference models. As explained in [6], the current IP4 terminology is an evolution of the IT2Rail ontology and can be aligned both to the IT2Rail model (influenced in turns by the FSM model) and to TRIAS. In the diagram in Figure 4, the current IP4 terminology is reported and, in brackets below the different concepts, a tentative direct mapping with the TRIAS specification. Even in this diagram, some components, such as the *Interoperability Framework*, providing communication capabilities between the TEs and the IP4 ecosystem, are not shown since they don't introduce relevant concepts for our analysis.

The most significant change is related to the new centrality of the concept representing the itineraries computed by a Travel Expert and related to the proposed set of Itinerary Offer Items. In IT2Rail, the core element was the Itinerary Offer Item, while now the *Itinerary* concept (*Trip* in TRIAS) gained an equally important role. This aspect, however, doesn't influence the need for having a unique interface between TEs and the SO.

The Shopping Orchestrator (SO) component in IT2Rail is now defined as *Travel Solution Aggregator (TSA)*. However, it has the same functionalities defined for the SO, even if some terminology has been re-defined. The TSA calculates a set of Travel Solutions that are

solutions provided to the customer, as the result of the Travel Shopping process, in the form of Itineraries and Offers. Itineraries are composed by the TSA considering the ones received by the TEs and are bound to the related ItineraryOffers covering a given Itinerary. An ItineraryOffer contains exactly all the Itinerary Offer Items for a given Itinerary, additional Offer Items bound to Ancillary Services may be composed to generate generic Offers proposed to the user. *User Preferences* are used by the TSA to filter Travel Solutions and by the Travel Companion to rank them before being shown to the user.

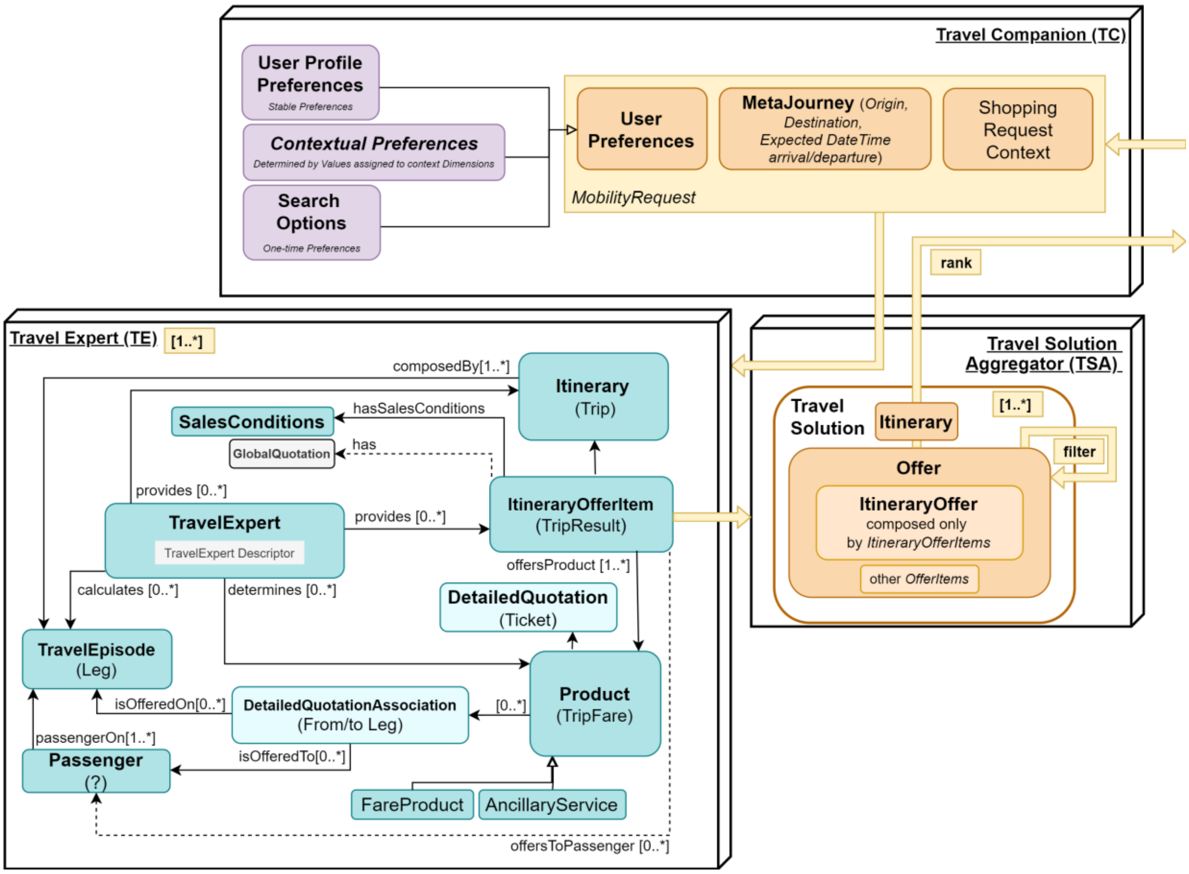


Figure 4 – Current IP4 Terminology alignment diagram

An important issue, emerged in this assessment of the current IP4 terminology, is that in TRIAS the concept of *Passenger* is missing. In Ride2Rail this aspect is fundamental, given that the proposed Itinerary Offer Item in a ride-sharing scenario should be bound to a univocally identifiable passenger (e.g., to be recognized by the driver) and cannot be sold to a generic passenger. Therefore, in the evolution of the IP4 terminology, this is an important aspect to be considered.

6.4. Catalogue of User Preferences in IP4

In *Table 2*, the catalogue of User Preferences currently managed in the IP4 solution is presented. Each group of elements has a different typology.

Contract No. 881825

Type 1 identifies groups where each element can get a different preference value. For example, in the group *class,* the user may express different values of preferences for each element of the group (e.g., first class = 0.2, business class = 0.6, economy class = 0.4). In this case, to facilitate the user in expressing her preferences, a star rating method is used to collect a value then mapped to the considered interval.
Type 2 identifies groups where the user can select only one element, *Type 3* identifies groups where the user can select multiple elements. In both *Type 2* and *Type 3*, the elements can not be associated with intermediary values but can get only 0 or 1 values.
Each group also has a *category* column indicating whether a given preference is associated with the User Profile or with the Journey. In this second case, it can be changed on a per-travel basis and can be related to a context or set as a search option.
In this context, preferences related to Trip-Tracking are not reported since this component is not relevant for our analysis.

Category	Group	Group Elements	Type
Journey	Preferred means of transportation	Train Airline Urban Coach Toll Park Car Sharing Bike Sharing	1
Journey	Preferred carrier	Trenitalia SNCF AirFrance VBB TMB Renfe RegioJet KLM Iberia FlixBus	1
Journey	Class	Economy Business First class	1
Journey	Interchanges	Slow Medium Fast	2
Journey	Refund Type	Automatic refund Manual refund	2
Journey	Seat	Aisle Window Large	1

Journey	Message Type	Information Warning	3
Profile	Loyalty/Reduction card	Cartafreccia FlyingBlue Tarjeta Dorada Card Grand Voyageur	3
Profile	PRM type	Older person Persons with impairments in movement skills/users of temporary wheelchair Persons porting a carrycots Persons with blindness or visual impairments Wheelchair users in mainstreaming seat Wheelchair users in specific seat named "h-seat" Pregnant women Persons with deafness or auditory impairments	3
Profile	PRM Path	No step Maximum one step No stairs No escalator No elevator Minimum 90cm passage	3
Profile	PRM Coach	No step Maximum one step Maximum gap between coach and platform <*x*>cm Minimum doorway <*x*>cm	3

Table 2 - *Catalogue of User Preferences in IP4*

In the current design, contextual preferences are simplified through the definition of *traveller profiles*. Each user can have one single user profile with stable preferences, but multiple traveller profiles with a specific set of preferences associated.

In the current implementation, a set of default *traveller profiles* (Basic, Business, Family, Leisure) with pre-initialized offers are proposed to the user during the registration. For example: (i) if the *Business* profile is chosen, the maximum preference value is associated with the *business* element of the *class* group, (ii) if the *Family* profile is chosen, the maximum preference value is instead given to the *economy* element.

The user may then decide to change *profile* or to select its own preferences. CFM projects have announced that, in future releases, the user will be able to create and manage the different *traveller profiles.*

7. FIRST CONCEPTUALIZATION OF CHOICE CRITERIA AND INCENTIVES

This chapter describes the first conceptualization of Offer Categories, User Preferences, and Incentives produced considering the state-of-the-art analysis and the IP4 terminology.
In Section 7.1, the first set of definitions aiming at conceptualizing choice criteria and incentives is presented. In Section 7.2, it is reported how the introduced concepts could be aligned with the current IP4 terminology.

The remaining parts of the chapter focus on identifying concrete instances for the defined concepts. In Section 7.3 and Section 7.4, the first catalogue of instances for Offer Categories and User preferences is proposed. These catalogues do not aim at providing a complete list of choice criteria but summarize contributions from the state of the art analysis and the IP4 alignment. According to Ride2Rail DoW, the final version of the catalogues will be published at M10 in "D2.4: Final conceptualization of choice criteria and incentives".
In Section 7.5, recommendations on Incentives for multi-modal travel Offers resulting from the state-of-the-art analysis are proposed.

7.1. Conceptualization

The first conceptualization of choice criteria (Offer Categories and User Preferences) and Incentives is presented in the following sections. For each term, a definition has been elaborated and agreed from Ride2Rail partners considering the state-of-the-art analysis and the IP4 alignment carried out. Moreover, preliminary definitions of IP4 components that should deal with these new concepts introduced by Ride2Rail are proposed. The provided conceptualization aims at extending the current IP4 glossary [20] and at supporting the development of the related ontologies.

7.1.1. Offer Category

An Offer can be described by a set of objective variables (such as transportation mode, level of CO_2-emission, cost, etc.). The values assigned to the objective variables and characterizing a given Offer represent ***features*** of an Offer. A ***feature*** can also be defined as a composition of sub-*features,* therefore, considering a set of objective variables.

An **OFFER CATEGORY** identifies a set of Offers having particular shared characteristics. The membership of an Offer to a given Offer Category is computed considering Offer features for a sub-set of the objective variables describing the Offer, i.e., the *determinant factors* for the Offer Category. The membership of an Offer to a given Offer Category is

defined by a ***Category Score*** **(CS)** in the range of [0,1][13], where 0 means "no membership", and 1 indicates "full membership".

An **OFFER CATEGORIZER** is a component offering a service to compute the Category Scores of an Offer with respect to a set of Offer Categories. It implements a set of functions that compute the Category Scores based on the Offers' *features*. The service receives as input the Offers and produces the ranked list of Category Scores for each Offer.

Different Offer Categorizers could be created with different characteristics. For example, different Offer Categorizers could implement different algorithms and consider different objective variables as *determinant factors* to compute the CS of an Offer for a given Offer Category, therefore providing different CSs.

7.1.2. User Preferences

The User Preferences conceptualization proposed in this section is based on the model currently adopted by IP4 and inherited from IT2Rail. The main difference is the proposal of definitions reconciling *user profile*, *search options, and contextual preferences* in a common model based on the concepts of *Context* and *User Preferences*. Basically, the idea is to consider all the preferences as *contextual* as follows: (i) the preferences included in the *user profile* and not associated to specific Contexts are preferences to be stably applied to all the different Contexts; (ii) the *search options* preferences selected when compiling a Mobility Request should be applied to the specific current context; (iii) *contextual* preferences are related to specific Contexts (identified by specific values associated with dimensions) and can be directly specified by the user or learned by the system using different approaches.

A **CONTEXT** can be described by a set of *dimensions* (and sub-*dimensions*), each one defining a set of admissible values. The Context *dimensions* (and sub-*dimensions*) depend on the domain considered. The current Context is identified by the set of current values associated with the Context *dimensions* (and sub-dimensions).

In Ride2Rail, the proposed conceptualization considers the Context as a broader concept identifying all the *dimensions* which are potentially relevant for the decision of a user in a specific situation. Therefore, it includes *dimensions* describing the context as in IT2Rail (cf. Section 6.2) but also some *dimensions* describing the user and the specific mobility request. This information can be useful to infer the user's preferences using data from other users with similar characteristics or similar mobility needs.

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[13] The range [0,1] is considered in all the definitions to indicate the normalization of a generic defined interval between a *min-value* and a *max-value*. Each interval may be used ensuring consistency.

Contract No. 881825

The USER PREFERENCES are a set of subjective *Preference Weights* (PW) associated with *features* of an Offer. For each possible Context, a different set of PWs can be expressed or identified for a specific user. These weights, defined in the range [0,1], represent the degree of desirability of an Offer feature for the user.

In the current IP4 Preference model (see Section 6.2), the values 0 and 1 are used as *Preference Weights* to express filter conditions: the value 1 represents a *mandatory requirement* and allows filtering out all Offers without the considered *feature*, while the value 0 denotes a *mandatory exclusion* and allows filtering out all Offers with the *feature*. This consideration is omitted from the definition since, in the general case, it is possible to assign specific PW outside the range to identify filter conditions and use the entire range to represent the desirability of the features for the user. In this case, 0 means “no interest for the feature”, and 1 means “maximum interest for the feature”.

An OFFER RANKER is a component offering a service to determine a ranked list of Offers considering as input the Offers and the User Preferences in the current Context. For each possible Offer, an *Offer Score* (OS) is calculated according to the Preference Weights and the Offer *features*. The service produces a ranked list of Offers considering the computed OSs.

Different Offer Rankers can use different algorithms to compute the OS (e.g., a simple normalized average of PWs associated to Offer *features* or more complex combinations), resulting in different ranked lists of Offers considering the same inputs.

7.1.3. Incentives

An INCENTIVE represents a method used to promote an Offer or a set of Offers over the others. An Offer Incentive is characterized by an *Incentive Provider*, an *Incentive Mechanism,* and a set of *Incentive Conditions*.

The ***Incentive Provider (Entity)*** represents the entity proposing and responsible (also legally) for a given *Incentive*. The *Incentive Provider* may be a TSP or an organization, an association, or a government body. The *Incentive Provider* determines the *Incentive Mechanism* and the *Incentive Conditions* for the *Incentive*.

The ***Incentive Mechanisms*** that can be defined are of two main types:

- ***Tangible*** *Incentive Mechanisms* to foster a user in choosing a given Offer providing a practical benefit (e.g., an ancillary product);
- ***Intangible*** *Incentive Mechanisms* to encourage the choice of a given Offer without employing practical benefits, for example, by simply providing additional information on the Offer to create awareness on the reason why a user should prefer it over the others.

An ***Incentive Condition*** is a binary function determining the applicability of an Incentive to an Offer for a user. The function takes as inputs a subset of the *features* characterizing the

Offer and a subset of the *User Preferences* in the current Context, to deterministically compute the applicability of an *Incentive* to a given Offer for a user. Particular cases are: (i) the Incentive may apply to any user, and User Preferences are not needed to determine the applicability, (ii) the Incentive may apply to any Offer related to a group of users and Offer *features* are not needed in the condition.

An INCENTIVE PROVIDER *(Component)* is the component representing the Incentive Provider and implementing the defined Incentive Conditions. Given a set of Offers, it determines the list of applicable Incentives defined by the *Incentive Provider* for each Offer and retrieves the information needed to apply the associated Incentive Mechanisms.

7.2. Choice Criteria and Incentives in the IP4 Context

In this section, the provided definitions are discussed considering the IP4 terminology described in Section 6.3. In Figure 5, the diagram outcome of the IP4 alignment is extended with the concepts defined in Section 7.1.

The *Offer* is the core concept of our conceptualization. Its internal description as a composition of Itinerary Offer Items and other Offer Items, and its relation with Itineraries to compose Travel Solutions, are the key elements to be considered in defining *Offer* features.

The *Offer Categorizer* component can be considered as an external service used by the Travel Solution Aggregator (TSA) to determine the Offer Categories associated with each Offer before forwarding them to the Travel Companion. The outcome of this process can be represented through the instantiation of a *belongsTo* property connecting the Offer to the Offer Category. As defined, this property should be characterized by a Category Score (CS). To implement, using an ontology, the association of the CS to the specific relation between the Offer and the OfferCategories it may be useful to instantiate an intermediate entity representing the relation. Ideally, different *Offer Categorizer* services may exist and the TSA can use more than one service to cover a broader list of Offer Categories.

Contract No. 881825

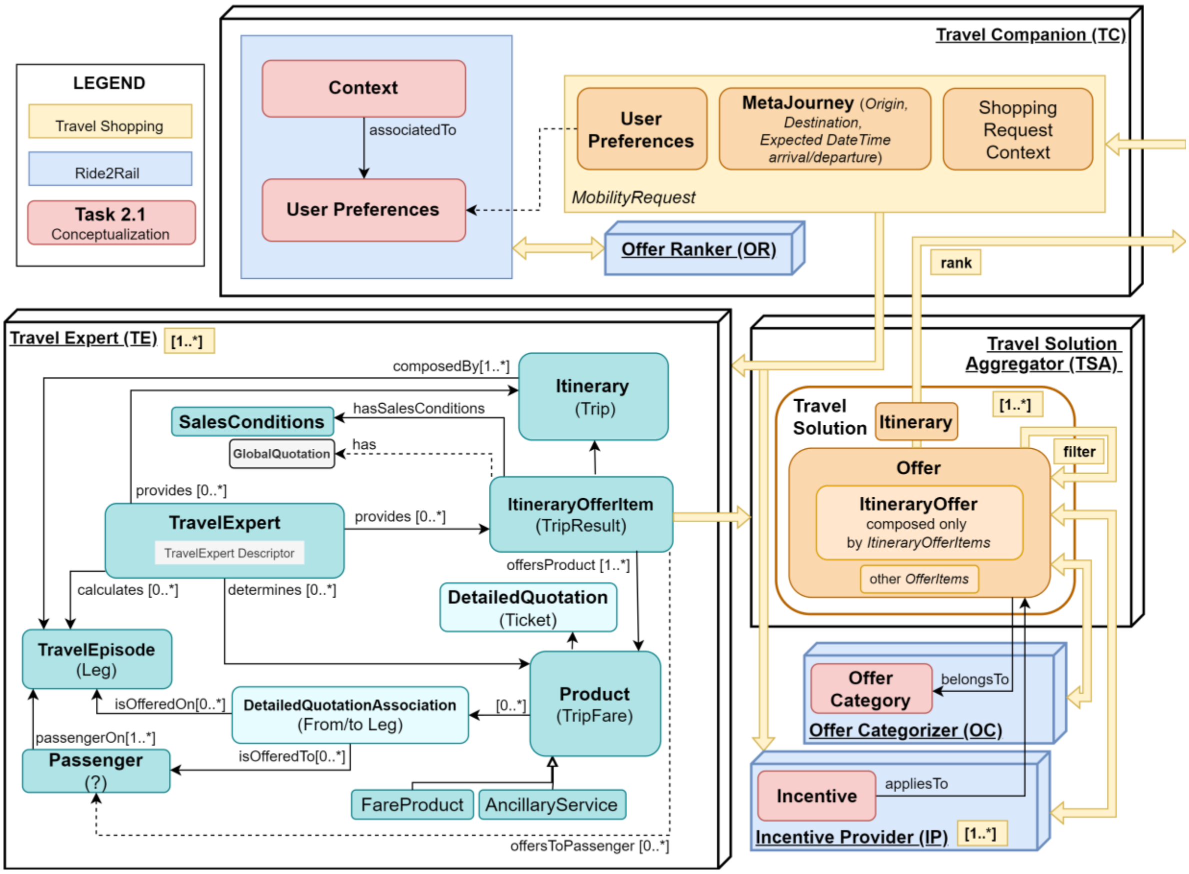

Figure 5 – Ride2Rail first conceptualization of choice criteria and incentives in the context of IP4 Terminology.

The *User Preferences* model is simplified integrating the concept of *user profile*, *search options* and *contextual preferences* as defined above. Each Mobility Request is associated with an instance of the User Preferences related to the current Context.
Preference Weights values describing the User Preferences in a given Context can be obtained directly asking for inputs from the user or learned from the user's data using different techniques and algorithms. However, this type of analysis is out of the scope for this deliverable and related concepts and components are not represented in the diagram.
The *Offer Ranker* is represented as an internal Travel Companion (TC) component but can also be implemented as an external service. The component is used by the TC to display to the user Offers, received in response to a given Mobility Request and already filtered by the TSA, in a ranked list based on User Preferences. Even in this case, multiple implementations of the Offer Ranker service can exist and, ideally, the TC may let the user choose among different *Offer Ranker*s.

The *Incentive Provider* components can act similarly to the Travel Experts. The TSA has available a set of *Incentive Provider* that can be contacted to determine *Incentive*s that can

be applied to the set of *Offer* generated. Differently from the *Offer Categorizer*, but similarly to the *Travel Expert,* this component may be interested in receiving information on the User Preferences. Assuming that *Incentive Provider*s may have different capabilities and may be interested in different typologies of Offers and in different sets of User Preferences, a mechanism similar to the one of the Travel Expert Descriptor may be adopted to help the TSA in handling the communications. The *Incentive Provider* implements the *Incentive Conditions* to determine the instantiation of an *appliesTo* property between the Offer and the Incentive. The *Incentive* instance refers to the related *Incentive Mechanism.*

An interesting issue emerged in the Collaboration Meeting with CFM partners related to the integration of *Incentive*s in the IP4 ecosystem. To provide some typologies of Incentives the *Incentive Provider* may need to stipulate contracts with TSPs (e.g., a government body willing to provide discounts on some TSP Offers), this type of interaction may be managed similarly to what is currently implemented in the Contractual Management Market Place (CMMP) to generate multimodal agreements and MaaS packages.

7.3. Catalogue of Identified Offer Categories

In this section, the first catalogue of Offer Categories is presented. The Offer Categories have been identified from the state-of-the-art analysis and subsequently framed considering the provided definitions. The goal is not to give an exhaustive list of all the possibly definable Offer Categories, but to elicit the most common ones to provide to the user a comprehensive clusterization of travel solutions obtained in response to a Mobility Request.

To define Offer Categories we consider here three conceptual levels: *objective variables* describing an Offer, *low-level Offer Categories* obtained considering objective variables, *Offer Categories* defined from multiple low-level categories.

Objective Variables

The works from Clauss et al. [30] and Zhao [35] identifies the typology of variables that can be considered to characterize Offers. Integrating the models proposed in the two studies, it is possible to identify the following macro-areas of variables:

- *Instrumental*: variables related to the measurable characteristics of the travel solution (cost, time, etc…)
- *Perception*: variables related to the users' perception while travelling (comfort, safety, etc…)
- *Symbolic*: variables related to the personal value attributed by a user to a specific travel solution (prestige, status, etc…)

The performed analysis of the state-of-the-art highlighted a set of variables, belonging to the identified macro-areas. However, while *instrumental variables* are objective and easily measurable, the same does not hold for *perception* and *symbolic variables*. The difficulty of obtaining an unambiguous definition of the concepts makes these factors harder to be defined appropriately. Nevertheless, quantification of *perception* variables could be evaluated through feedback collected from an adequate statistical sample of users, e.g.

measuring the feeling of personal safety or the level of comfort. The same does not hold for *symbolic variables* that are more subjective and, for this reason, can not be considered to characterize Offers for a generic user.
Therefore, we can define *instrumental* and *perception* variables as potential *determinant factors* that can be used to determine the membership of an Offer to an Offer Category.

Low-level Offer Categories

Considering *instrumental* and *symbolic* macro-areas, we selected a list of objective variables describing an Offer that can be used as *determinant factors* of *Low-level Offer Categories*. For example, the total travel time variable is the determinant factor for a *Low-level Offer Category* that minimizes the said travel time identifying the quickest solution.
The complete list of *Low-level Offer Categories* identified and the related determinant factors are reported in *Table 3*.

Determinant Factors (variable)	Low-level Category
Total travel time	Minimize the total travel time
Frequency of the service	Maximize the frequency of the service
Stops required	Minimize the number of stops required (e.g., train/bus stops)
Total travel distance	Minimize the total travel distance
Variability of travel time	Minimize the variability of travel time
Waiting/Idle times	Minimize the waiting/idle times in the solution
Traffic congestion likelihood	Minimize the likelihood of traffic congestion on the route in the time range considered
Accident or breakdown likelihood	Minimize the likelihood of accident or breakdown
Influence of weather on travel time	Minimize the influence of weather on travel time
Total cost of the trip	Minimize the total cost of the trip
Integrated fare	Provide an integrated fare system
CO_2 emissions	Minimize CO_2 emissions per kilometre per passenger
Charity/Volunteering activities	Involve charity/volunteering activities (e.g., donating a part of the ticket price to charity)
People sharing the travel	Maximize the presence of people sharing the trip
Transfers required	Minimize the number of transfers required between different segments of the proposed travel solution
Different means of transport	Minimize the number of different means of transport involved in the travel solutions
Distance on foot	Minimize the distance on foot
Distance to drive	Minimize the distance the user has to drive

Contract No. 881825

Distance from start/stop location	Minimize the distance from start/end location required and first/last segment of the travel solution
Protection from bad weather	Maximize the protection from bad weather
Personal Safety Feeling	Maximize the feeling of personal safety
Level of privacy	Maximize the level of privacy
Overcrowding likelihood	Minimize the likelihood of overcrowded vehicles in the time range considered
Cleanliness of vehicle	Maximize the cleanliness of vehicle and station
Internet Access	Provide internet access
Space Available	Maximize the space available

Table 3 - *Catalogue of low-level Offer Categories*

Offer Categories

From a usability point of view, the determinant factors identified might be too many to be adequately managed and implemented in an easy-to-use interface. For this reason, Ride2Rail decides to cluster these low-level categories in a set of ten macro-categories, explained below, that present, as determinant factors, a subset of the ones mentioned above. Macro-categories identified are:

1. Quick
2. Short
3. Reliable
4. Cheap
5. Door-to-door
6. Comfortable
7. Social
8. Multitasking
9. Environmentally Friendly
10. Philanthropic

The ***Quick*** category measures how convenient and efficient the solution is in terms of time-related issues, considering the total travel time, the frequency of service, the waiting time between legs and the number of stops required. If the solution includes a segment on-road (e.g., bus/car) and real-time data on traffic congestion are available, also these data can be taken into account.

The ***Short*** category focuses on minimizing the distance covered.

The ***Reliable*** category concerns the likelihood of delays, traffic congestion, breakdowns or last-minute changes that could affect the travel time and comfort of the trip. Some solutions are inherently variable (e.g. traffic delays when crossing a city at rush hour), while other solutions might offer a small window to change the mode of transport that could cause massive idle times. Lastly, the influence of the weather on the trip is taken into account.

The *Cheap* category concerns the total price of a trip, the possibility of sharing part of it with others and the ease of payment, giving additional value to solutions that offer an integrated fare system and do not require the user to purchase different tickets from different platforms.

The *Door-to-door* category covers the distance of the user's start and endpoint from the beginning and destination locations of the solution provided. It is measured by the amount of walking or driving distance the user has to cover.

The *Comfortable* category, as stated before, is hard to be objectively defined. While it concerns objective factors such as weather protection, the number of transfers required, and the number of different means of transport used, it also covers a set of other elements about the quality of the trip that has to be evaluated through users' feedback. Based on the literature, this category should consider the likelihood of overcrowded vehicles, the feeling of personal safety, the level of privacy and the cleanliness of the stations and vehicles used.

The *Social* category concerns the maximization of the number of people the user will share the trip with and his/her ability to network or socialize based on the context and means used.

The *Multitasking* category concerns the extent to which the user can perform other tasks while travelling. These activities can regard productivity (personal or work), fitness, or enjoyment. This category considers the amount of space available, as well as whether the internet connection is provided. Lastly, the level of privacy might also influence the extent to which a person can work and could be considered as a determinant factor for this category.

The *Environmentally Friendly* category covers the green aspects of the trip, taking into account at least the amount of CO_2 emissions measured per kilometre/traveller for each mean of transport included in the Offer and considering the distance covered and the number of passengers. If available, additional determinant factors can be considered as the energy consumption, the NOx emissions (nitrogen oxides) and the carbon footprint.

Finally, the *Philanthropic* category relates to the willingness of the user to choose a solution that contributes to social causes or involves volunteering or charity activities (e.g., donations).

7.4. Catalogue of Identified User Preferences

The Context Dimension Tree (CDT) presented in Section 6.2 is a generic methodology to describe a context and its dimensions. To support and enrich the conceptualization of User Preferences currently implemented in IP4 and considering the state-of-the-art analysed, a CDT specifically related to the considered domain and focusing on the *Travel Shopping* process is presented in Section 7.4.1.
In Section 7.4.2, additional suggestions from the literature review are detailed as possible extensions of the User Preferences conceptualization.

Contract No. 881825

7.4.1. Traveller Context Dimension Tree

The designed Traveler Context Dimension Tree (TCDT) combines both Context dimensions and User Preferences, considering all of them as dimensions influencing the user's decision. As commented in Section 7.1.2, the Ride2Rail conceptualization of User Preferences defines a set of *Preference Weights* bound to the current Context. User Preferences in the TCDT can be directly used as *Preference Weights (PW)*. Moreover, together with other dimensions (describing the user, its needs, and the current situation) can also be used to infer PWs using

data from other users collected considering a similar TCDT. The proposed TCDT is depicted in Figure 6.

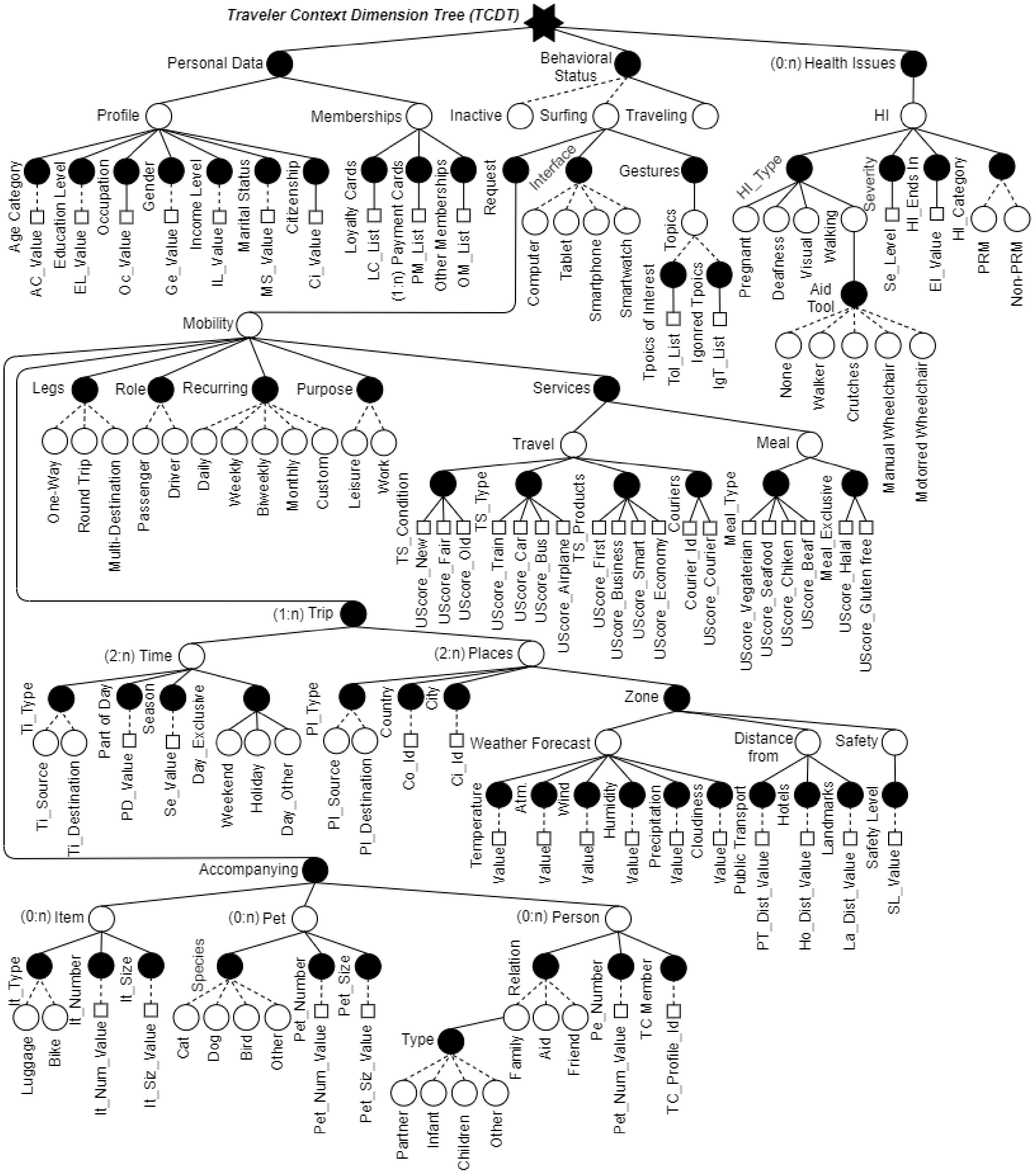

Figure 6 - Proposed Traveler Context Dimension Tree. Black circles represent dimension nodes and white circles and squares represent concept nodes. Dashed lines indicate mutually exclusive concepts.

The described TCDT does not aim to model all the dimensions that could be considered. Furthermore, it does not aim to state implementation choices, such as data structure to be used. The ultimate purpose of the proposed TCDT model is thus to support the analysis of such domain knowledge, including current IP4 implementation of User Preferences and outcomes from the state of the art analysis. The TCDT defines the fundamental dimension and concept nodes in such a way that any further interesting features can be added by increasing/decreasing the level of granularity of the model.

In the proposed TCDT, the Dimension Node (N_D) Personal Data captures the socio-economic characteristics of the users through the Concept Node (N_C) Profile and Memberships.

The values of the Profile N_C can be used to infer PWs associated to the Context from data of similar users based on different identifiable groups, such as users with the same geographical origin, the same profession, and so on. Considering an actual system, these dimensions can enable a warm start for a new user providing an initial set of preferences based on data collected during the user registration. As an example, consider two regions X and Y, for some reason, users from X can tend to choose some means of transport much more frequently than users from Y; not having additional information on a user from region X, it is possible to use this information to assign a higher PW to some means of transport for that user.

The Memberships N_C captures the memberships of the user to some communities. For example, the Loyalty Cards N_D captures membership of the user in a community that provides specific discounts; the Payment Cards N_D describes cards owned by the user identifying the community of users using a given payment method (e.g., able to pay using a specific payment circuit). These type of values can be used directly as preferences as in IT2Rail (e.g., to promote Offers linked to TSP of which the user has a Fidelity Card), but can also be considered as part of the Context to infer PWs as explained for the Profile N_C. Moreover, N_D Other Memberships is introduced as a placeholder to capture other, less structured communities.

Particular attention is given on detailing dimension describing the needs of people with disabilities and health-related issues (HI), the Health Issues N_D is defined to this purpose. The HI_Category N_D distinguishes if the issue belongs to the PRM (*Person with Reduced Mobility*) category. The descendants of HI_Type N_D list some of the most critical issues. Moreover, the TCDT increases the level of granularity for the Walking N_C through the Aid Tool N_D to exemplify the concepts which should be considered during the future expansion. Knowing this concept is essential because of the particular space each of the Aid Tools set as a requirement in considering different travel solutions. The same importance is also applied to the *Severity* N_D, which can potentially limit the travel choices. Lastly, HI_Ends In N_D, enables the TC to determine if the issue is permanent or temporary.

Among the other top dimensions, Behavioral Status captures the current situation of the user. The Traveling concept captures the state in which the user is travelling, or has purchased a travel offer and is waiting for the upcoming trip. Its two sibling N_C, drawn with dashed lines, are mutually exclusive: the Inactive N_C is true if the user is not interacting with the TC, while the Surfing N_C incorporates both implicit and explicit momentary user behaviours while interacting with the TC. More precisely, the Interface and Gestures N_D capture implicit behaviours that can be used to infer, for example, the typology of the device (e.g, mobile or desktop).

Contract No. 881825

Explicit behaviours, instead, are captured via the Request N_D describing the current Mobility Request. In this node, among the other dimensions, aspects specifically related to ride-sharing are considered. For example, considering a travel offer that may include a segment by car, the user may want to specify preferences on the Role, as *Driver* or *Passenger*, to explicit her preference on offers involving ride-sharing solutions. This information can be combined with their Purpose, Legs and Recurring dimensions applicable to any Mobility Request. The user provides the locations that they are going to visit (at least source and destination). In the TCDT, this value is transformed into appropriate concepts such as Country, City, and Zone. For example, the Zone N_D enables the TCDT to capture the factors contributing to the user's decision through its children nodes *i.e.* Distance from Public Transportation services, Hotels and Landmarks (PT). The same strategy is applied to transform the actual value of the requested departure and arrival times to the Time NC and its descendant nodes. Moreover, the Weather Forecast N_C is used to capture weather information according to the Time when the user will be in that Zone.
The user may have some Accompanying Items (e.g., a bike) and Pets, whose characteristics such as their *Type*, *Species*, *Size* and *Number* can be considered to determine user's preferences. Also, accompanying Persons not only affect travel choices from the logistic aspect but, if the Person is also a user of the TC, their preferences should be considered for recommending trips.
The Services N_D encompasses the variety of Travel- and Meal-related preferences according to the user's PWs that can be directly provided by the user (*optional)* or generated analysing user's historical data.

The presented TCDT is a model that explores Context and User Preferences as a single representation. This supports, given a Mobility Request, the analysis of dimensions that can be used to collect and infer Preference Weights associated with the current Context. The described TCDT encompasses all the User Preferences currently implemented in IP4 and presented in Section 6.4, providing a more detailed conceptualization. In particular, the tree focuses on broadening the set of considered dimensions and omits some details, like the one related to PRM described in Table 2, that can be represented considering further granularity. Trip Tracking preferences are omitted, since they are out of the scope of this deliverable, but can be integrated as additional dimensions in the proposed model. The last aspect to be commented is related to the Profile Categories currently implementing a simplified view of the Context as discussed in Section Catalogue of User Preferences in IP46.4. These categories can be added as dimensions describing the Context or can be considered separately as "labels" identifying pre-determined values for specific dimensions in the TCDT.

7.4.2. Additional User Preferences

This section includes additional User Preferences identified in the literature review that could be considered to enrich the proposed TCDT. The final version of the TCDT will be described in "D2.4: Final conceptualization of choice criteria and incentives".

Contract No. 881825

A first important aspect emerging from the literature and projects analysed is related to the study of *attitudes and personality* of the user to offer more tailored preferences. The TCDT proposed may be expanded considering attitudes, e.g. lifestyle, social responsibility or involvement towards the environmental cause. Moreover, the described My-TRAC project (see Section 5.2.3) offers a concrete example of how users' personality traits can be collected through a set of questions and used to cluster users. The composed clusters can be used to infer the User Preferences of people belonging to the same group.
Related to the lifestyle and attitudes of the user but more difficultly implementable, the approach evaluated in the BONVOYAGE project (see Section 5.2.2) can be considered. Assuming the availability of bio-sensors gathering data on the user (e.g., through smartwatches) during the travel, it is possible to monitor stress, fatigue, and other physical parameters to infer user preferences.

A second aspect is related to the analysis of the *user's interests*. Asking directly to the user or assuming additional data sources, e.g. integration with social networks, it is possible to collect data that can be used to compare preferences of users with similar interests. A similar strategy may also be applied to analyse the history of locations visited by a user that can be clusterised according to Point of Interests (POIs) in the surroundings, and preferences of users visiting similar places can be compared.

An additional aspect highlighted in our state-of-the-art analysis is related to a set of preferences that a user may want to express but that are often not provided by TSPs when looking for offers. These preferences include pre- and after- travel services and services for productivity (like plugs and internet connection). Additional preferences may also be specified in the context of ride-sharing, letting the user defining preferences on the driver/passengers profile (e.g., age range, gender).

The last aspect that can be considered directly connects Offer Categories and User Preferences. A set of Preference Weights may be associated by the user to the different Offer Categories. This can be considered as an additional input for the Offer Ranker.

7.5. Recommendations on Incentives

Considering the state-of-the-art analysis, Section 7.5.1 proposes a set of recommendations to define Incentives for multi-modal travel offers. The proposed recommendations consider the multiple facets of the Incentive concept, highlighted in Section 5.3, declining them in the domain considered in Ride2Rail. As discussed in Section 7.1.3, it is the responsibility of the *Incentive Provider* to determine mechanisms and conditions for the Incentives. For this reason, the definition of a comprehensive catalogue of incentives, as done for Offer Categories or User Preferences, is neither possible nor useful in the context of Ride2Rail and, more generally in IP4. For this reason, the list of incentives reported in Section 7.5.2 has to be considered not as a catalogue but as examples to support the explanation of the proposed conceptualization (Section 7.1.3).

Contract No. 881825

7.5.1. Incentivize Multi-modal Travel Offers

A first approach that can be considered is the one concerning the behavioural change (see Section 5.3.1), trying to pinpoint cognitive biases and factors influencing the decision-making process.

One way to frame this problem is provided by the EAST Framework, that, to this end, adopts four different strategies: make it Easy, Attractive, Social and Timely. This promotes the usage of simplified and known options to increase uptake, implementing rewards to spark interest, exploiting social relationships to spread and support commitments and behaviours and, lastly, understanding the best moment to propose the action. Notably, data shows that there is no "one size fits all" solution and, based on the context and target audience, different parallel strategies should be adapted and used to both spread the message and try to advance changes.

A different model, the "Behavioural Change Wheel", states that new behaviours arise from three different sources that should be aware of the characteristics of the target population for the incentives. The first one, *Capability*, remarks on the importance of knowing or learning specific skills or capabilities before changing a behaviour. Secondly, *Motivation* in terms of setting goals and planning desired outcomes is required and, lastly, an *Opportunity* is needed in the form of an enabling environment that pushes the desired behaviour.

When understanding the motivation behind a choice or behaviour, it is important to define and distinguish intrinsic and extrinsic motivation. The first one describes actions taken simply because they are inherently interesting or enjoyable without the need to look for a secondary outcome. On the contrary, separable outcomes, such as monetary rewards, are categorized as extrinsic motivators.

Intrinsic motivation leads to greater engagement and better results over a longer period, but needs to be backed up by extrinsic motivators to incentivize people to do tasks that do not appear inherently interesting or enjoyable to them, thus expanding its reach and efficiency. Extrinsic motivators might push users into trying a new activity they wouldn't have done otherwise (e.g., the promotion of ride-sharing via specific rewards). Once users try it, they might discover it is quite interesting and enjoyable and keep using the service solely based on their now sparked intrinsic motivation.

Another, different, approach to incentivize the adoption of a specific behaviour regards targeting people with a pre-existing interest towards non-financial issues, such as health or environment. On average, people tend to enhance their self-image by promoting their best behaviours concerning social, health or environmental matters as well as their ability to save time or money.

At the same time, people are more influenced by negative impacts, or losses, rather than by gains. This effect is defined as "loss aversion" or "gain-loss asymmetry" and could be exploited, paired with a person's willingness to promote his/her self-image, by highlighting the bad aspects of a given behaviour instead of emphasizing the positive ones, like showing the increase of CO_2 consumption of a specific transport solution instead of the amount a different option would save.

Furthermore, whenever an analysis of the user's behaviour is possible, personalized incentives can be constructed and customized based on the gathered information on the user's preferences and history. An example of said customized extrinsic motivators is the offer of discounts on specific days or routes that the traveller often purchases, or even the discount of a "higher class" ticket in order to stimulate the customer to try the upgraded service.

Finally, to increase users' engagement and interest in an offer, elements typically found in games can be applied to real-world or productive activities and, to do so, the Octalysis Gamification framework (cf. Section 5.3.5) was defined. It identifies eight core drivers that influence every activity a person performs, such as scarcity or avoidance, which respectively indicate the desire of something that cannot be possessed and the willingness to avoid some negative happening.
The framework suggests a declination of the drivers based on the phase they characterize (e.g., the launch of the Ride2Rail solution) and to consider all the different player types to be aware of the level of motivation they have during the several stages of the experience.

7.5.2. Examples of Tangible and Intangible Incentives

This section provides examples of Incentives for multi-modal travel offers. The provided examples do not aim at providing a comprehensive catalogue but aim at offering concrete instances in the domain considered and at clarifying the distinction introduced between *tangible* and *intangible* incentives.

Examples of tangible incentives are:

- Immediate price discount on a given travel offer.
- Discounts on the following purchases if a given travel offer is chosen.
- Point Accrual associating points with travel offers, points earned can be converted to prizes (e.g., Loyalty programme).
- Direct prizes assigned for specific travel offers.
- Ancillary services for free or discounted (e.g., meal).
- Discounts on complementary services (e.g., hotel).
- Discounted or free upgrade of the travel class.

Examples of intangible incentives are:

- Provide to the user information that can increase her/his awareness on the environmental sustainability of a travel offer (e.g. displaying the CO_2 emissions).
- Adopt a gamification strategy assigning badges to award the achievement of pre-defined goals (e.g. trying a ride-sharing solution for the first time, or choosing the solution with the lowest environmental impact).
- Assign points to the users for virtuous choices in travel offers and set up a daily/weekly/monthly shared leaderboard (e.g., among friends).
- Provide to the user additional material promoting a given travel offer, e.g., include in an offer involving a bus the images of city monuments that can be spotted during

Contract No. 881825

the travel. This can allow for example to promote the bus over the underground, even if the second solution may be faster.

- Devolve a percentage of the travel offer price to charity/voluntary organizations.

Contract No. 881825

8. CONCLUSIONS

The deliverable presented the first conceptualization of choice criteria, i.e., Offer Categories and User Preferences, and Incentives for multi-modal travel offers. The proposed conceptualization has been supported by two main activities reported in the document, the state-of-the-art analysis and the alignment with the Shift2Rail IP4 work programme to which the conceptualization should contribute.

The methodology adopted for the state-of-the-art analysis involved all the partners in the collection of potentially relevant sources (e.g., research papers, project deliverables). The related chapter presented contributions from the literature and from pertinent projects of which Ride2Rail partners were involved in. The analysis of state-of-the-art on the conceptualization of Offer Categories focused on contributions proposing mechanisms to classify multi-modal travel Offers and identifying variables to be considered for Offer categorization. The analysis of state-of-the-art on User Preferences concentrates on the identification of studies and projects investigating how to propose tailored offers to a specific user considering her/his preferences and how they change in different contexts. Moreover, special attention was given to systems providing personalized offers to the users. The analysis of state-of-the-art on Incentives focused on the various facets used to characterize the Incentive concept in different research areas. In particular, we considered studies on frame factors influencing behavioural changes, the role of motivation in incentivizing a given behaviour, the use of non-financial incentives, the effectiveness of personalized incentives tailored to the specific user, the adoption of gamification strategies, and insights on incentives for shared travels solutions.

The deliverable reported the outcomes of the collaboration meetings with IP4 CFM projects to identify the current terminology in the IP4 ecosystem relevant to the Ride2Rail conceptualization. The alignment has been restricted to the Travel Shopping and Travel Companion ontologies, i.e., the models referring to the process of a user with a mobility need and looking for multi-modal travel offers (Travel Shopping) through its personal application (Travel Companion). The alignment resulted in the production of a diagram representing the main IP4 components involved in the Travel Shopping, and, for each of them, the set of concepts and relations that are handled by that component. The diagram clarifies that, concerning choice criteria and incentives, the current terminology include only a *context-aware* model for User Preferences, inherited from the IT2Rail project. The model has been described in details and considered as a solid basis for the Ride2Rail conceptualization of the User Preferences.
An important issue emerged from this alignment is related to the importance of taking into account the concept of Passenger in the evolution of the IP4 terminology. In ride-sharing offers, it should be possible to univocally identify and describe a passenger (e.g., to be recognized by the driver) so this concept must be modelled and cannot be simplified/omitted as in other standards (e.g., TRIAS) currently considered in IP4.
As a last result of the alignment activities, since the IP4 ontology is currently undergoing an in-depth process of modularization and extension, it has been decided to propose the first

conceptualization of choice criteria and incentives as an integration of the latest release of the IP4 terminology glossary defined by the MaaSive project.

The first conceptualization of Offer Categories, User Preferences, and Incentives resulted in (i) definitions elaborated and agreed between Ride2Rail partners considering the state-of-the-art analysis and the IP4 alignment carried out, and (ii) new components that should be introduced in IP4 to deal with the conceptualized terms.

The Offer Category has been defined as a class of Offers definable through a set of *determinant factors*. The *Offer Categorizer* has been introduced as the component responsible for implementing algorithms to assign Offer Categories to Offers.

The User Preferences model from IP4 has been simplified describing each preference as a *preference weight* measuring the desirability for a user in having specific characteristics of an Offer. The set of *weights* is defined considering a specific *Context* describing the current situation in which the user is involved. The *Offer Ranker* has been introduced as the component responsible for implementing algorithms to rank Offers for a user given his/her *preferences weights* in the current *Context*.

Incentives have been characterized through the definition of (i) the *Incentive Provider* concept, representing the entity proposing and responsible (also legally) for a given Incentive, (ii) the *Incentive Mechanism* concept, defining the way used to incentivize an Offer, and (iii) the *Incentive Condition* concept, defining the rules determining the applicability of an Incentive to a given Offer and a given user. The *Incentive Provider* has also been defined as the software component proposing Incentives for the related entity.

The conceptualization has been complemented by identifying a preliminary list of concrete instances for each defined concept. The first catalogue including ten Offer Categories and related *discriminant factors* has been proposed. User preferences and Context description have been analyzed through the introduction of the Traveller Context Dimension Tree (TCDT), extending the current set of preferences implemented in IP4, and through the identification of additional User Preferences emerging from the state-of-the-art. For what concerns Incentives, a collection of recommendations to incentivize multi-modal travel offers have been proposed together with some concrete examples of *tangible* and *intangible* incentives.

The proposed conceptualization will be validated by surveying transport users to check if it is compliant with their needs and expectations. The results of the survey will be presented in the “D2.4: Final conceptualization of choice criteria and incentives”, together with the final version of the conceptualization.

Contract No. 881825

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