THE LINKINGDANUBE CONCEPT

A guide for linking multimodal traveller information services across borders

01/01/2017 – 30/06/2019

LinkingDanube – Linking transnational, multimodal traveller information and journey planners for environmentally-friendly mobility in the Danube Region

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PREFACE

A major requirement towards innovation and deployment of new solutions in transport is to shape future mobility in an intelligent and sustainable manner. This has been acknowledged throughout the whole European Union and stakeholders are working on it on different levels and across regional and national borders.

The linking of traveller information services represents an integral part in the vision of efficient and sustainable mobility. It means that existing services can persist while being enhanced in terms of coverage and functionality through the linking with other services. The systems only have to exchange routing requests and results and therefore maintain sovereignty over their own data. This facilitates the provision of travel information in highest quality, richness and actuality to travellers as they are subject to the data maintenance processes of the source systems.

A European perspective in terms of legislation and funding continues to be a crucial enabler for sustainable solutions. The concept of linking services has already found its way into European legislation. As a financing instrument of the European Territorial Cooperation (ETC), the Danube Transnational Programme (DTP) provides a framework for the implementation of necessary initiatives between national, regional and local actors from different Member States. In order to increase territorial integration of the very heterogeneous Danube Region the programme acts as a policy driver for tackling common challenges where transnational cooperation is needed. On strategic level, the EU Strategy for the Danube Region (EUSDR) was jointly developed by the European Commission, the Danube Region countries and stakeholders in order to address common challenges – such as the linking of services – together. The strategy seeks to create synergies and coordination between existing policies and initiatives across the Danube Region.

With this background and six Danube Region Member States willing to take the next step, the time has come for spearheading initiatives: The project LinkingDanube. This multi-Member State action will pilot and thereby prove the feasibility of linking services in a cross-border setting.

This concept you are now reading consists of four chapters. The first chapter presents general aspects to be considered when linking traveller information services and outlines basic organisational and legislative aspects of demand-responsive transport as a supplementary element to the linking of services. Chapter 2 gives an introduction to the CEN/TC 278 technical specification "Public transport – Open API for distributed journey planning" and possible system architectures for implementing a linking services approach. Chapter 3 shows the application of the linking of services within the project LinkingDanube as well as the project use cases and the system architecture.

The purpose of this document is to work as a whole as well as to have each of its three chapters standing for themselves. In this way readers can learn about linking services and demand-responsive transport in general as well as about technical aspects and further details explained in the course of the project LinkingDanube. As such, it shall be a guide towards the implementation of linking services and display possible ways to get there.

It is perfectly legitimate to say that LinkingDanube benefits the Danube Transnational Programme in several ways: On the one hand, it contributes to a higher degree of territorial integration through genuine transnational cooperation. On the other hand, it benefits the addressed regions and their inhabitants as well as occasional travellers who will enjoy the new refined information service. The practical and functional integration of the project results in real life, their alignment to the applicable regulations as well as employment of latest technologies are fully convergent with the Programme's principles of result-orientation, harmonised comprehensive approach and sustainable development through innovative solutions.

Ana Leganel, Project Officer, Danube Transnational Programme

Linking travel information services, as shown in the project LinkingDanube, fully tackle the deployment priorities of the Danube Region: We need to ensure access to public transport data via a harmonised interface and provide seamless multimodal traveller information service for the citizens of the Danube Region. One of the most important goals of EUSDR is the territorial cohesion that should be achieved by established links between urban and rural areas as well as fair and affordable access to infrastructure and services. In this context LinkingDanube contributes to the EUSDR goal to better connect citizens, to support multimodality and better connected transport links.

Franc Zepic, representative of the European Danube Region Strategy (EUSDR), coordinating Priority Area 1b

In our role as operator, KORDIS JMK highly welcomes the possibility to participate on the LinkingDanube project. We consider the testing of a multimodal cross-border journey planner as very practical and desirable since such a solution is missing in our region. The new demand services can also help us in providing better public transport in the less populated areas, especially as a cross-border service. We regard this initiative as a great opportunity for our customers. Using the principle of linking services, they can use our service for better travelling across the Danube Region and can obtain all-in-one information on their individual trips.

Květoslav Havlík, deputy director of KORDIS JMK

1. DISTRIBUTED MULTIMODAL JOURNEY PLANNING FOR THE DANUBE REGION

1.1. *Rationale*

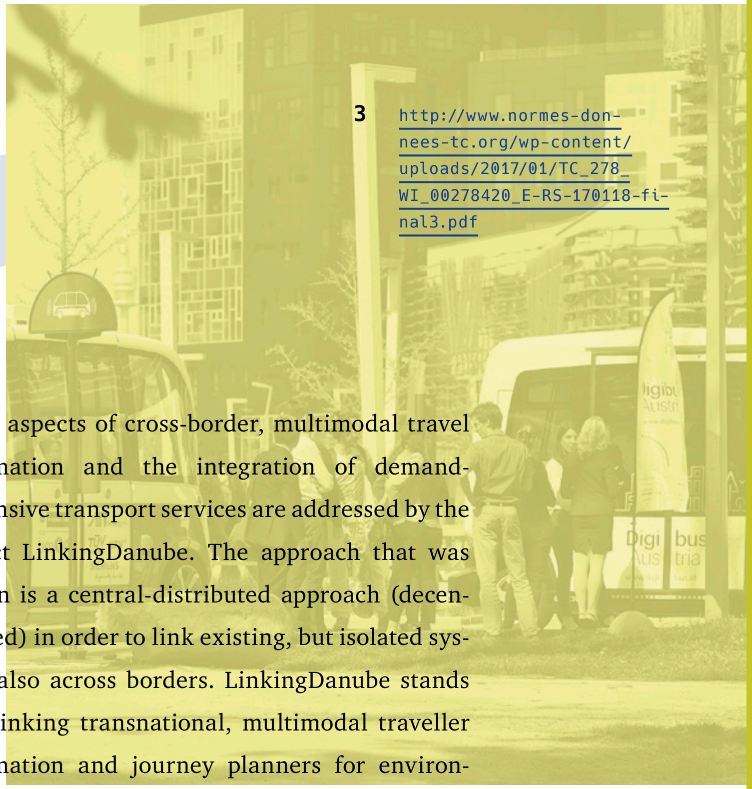
Throughout the European Union (EU), traffic volumes keep growing with a prospected increase of passenger transport of over 30% by 2030 and more than 50% by 2050.[1] This is accompanied by the fact that public transport infrastructure is not equally developed in all EU member states. In urban areas the concerned authorities have to deal with growing volumes of traffic on infrastructure that is not always capable of handling all transport demand without delay – not even nowadays. This requires measure on two levels: On the one hand there are certain bottlenecks that need to be removed through building new or improving already existing infrastructure. In contrast, rural areas suffer from the fact that public transport infrastructure is often not economically viable due to low passenger potential in peripheral regions. This leads to high car dependency of residents in such areas. On the other hand it will be vital to manage traffic more efficiently and exploit the full potential of transport infrastructure without necessarily upgrading it physically.

Several documents and roadmaps issued by the European Commission – such as the 2011 White Paper on transport[2] – describe the goal of reducing emissions and increasing efficiency in the field of European transport. Being an inherent element of this European vision, Traveller Information Services have been in the scope of various European ITS (Intelligent Transport Systems) projects on technical and organisational level. For contributing to the goal above, the European Commission strives for convergence of these services across national and regional borders into a Single European Traveller Information Service that would offer a consistently high quality and continuity of service to end users across the whole European Union.

One way to tackle this is by improving information about multimodal and public transport mobility options and by offering high quality of services in combination with availability of connections, thus attracting users to multimodal mobility. However there are numerous multimodal information systems across Europe. These are limited in regard of the geographical scope and cross-border information is hardly integrated. There is a need for seamless journey planners for public transport, which are going beyond the local or regional system boundaries. This deficiency must be viewed against the huge cross-border travel demand within the European Union leading to about one hundred millions of cross-border trips every year by EU residents and a further several hundred million trips by international tourists. Understandably, the lack of information on public transport for door-to-door routing affects the mobility behaviour of all kinds of transnational travellers, especially of cross-border commuters who abandon public transport options and use their car instead. Hence there is a need for cross-border information on public and multimodal transport solutions.

1 http://europa.eu/rapid/press-release_MEMO-11-197_en.htm

2 https://ec.europa.eu/transport/sites/transport/files/themes/strategies/doc/2011_white_paper/white-paper-illustrated-brochure_en.pdf



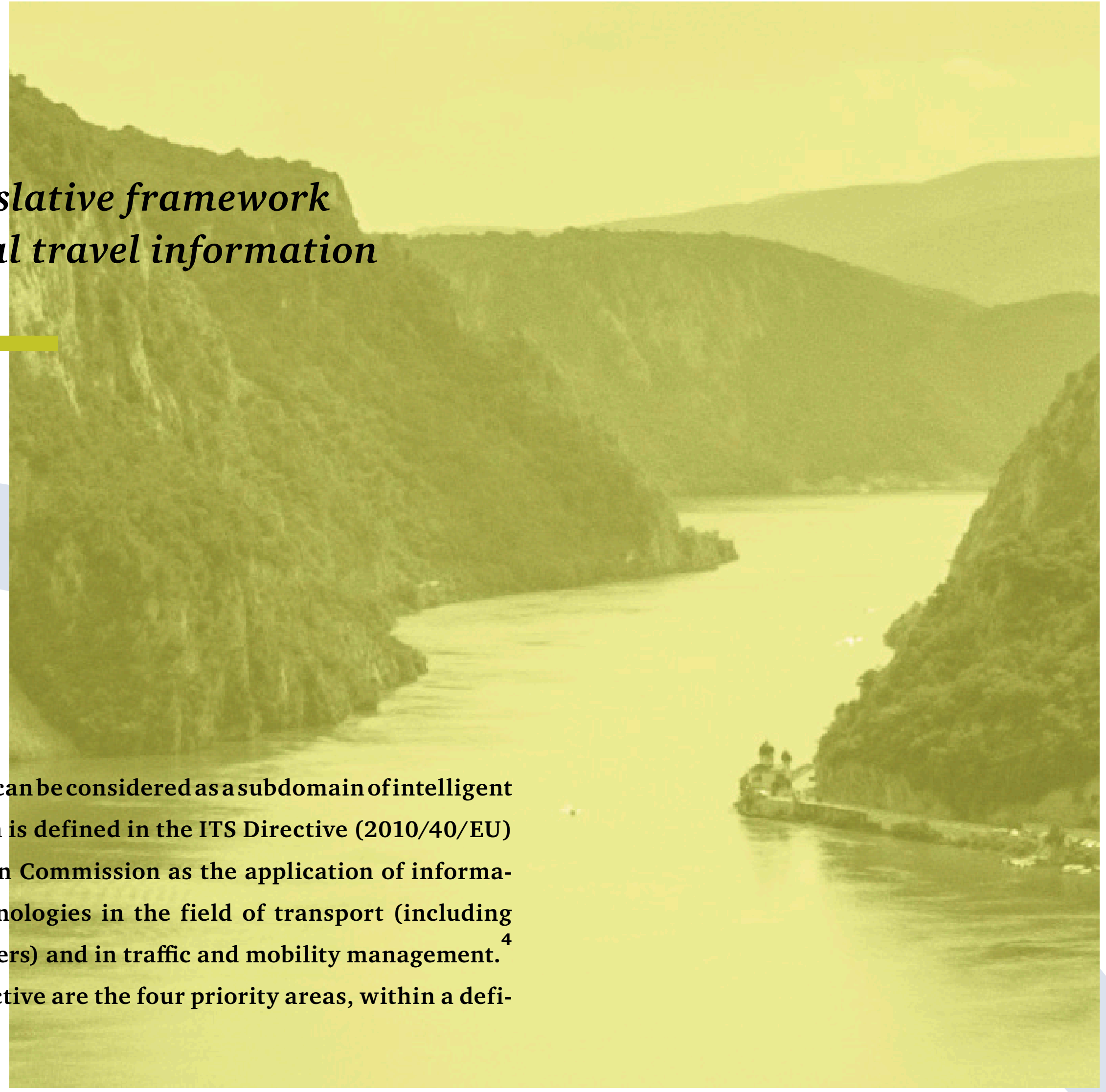
3 http://www.normes-donnees-tc.org/wp-content/uploads/2017/01/TC_278_WI_00278420_E-RS-170118-final3.pdf

In this respect multimodal transport solutions should not be limited to traditional, line-based public transport only. Certain regions face specific demands for mobility which cannot sensibly be fulfilled by conventional public transport solutions. This applies in particular to rural areas, of which some have a transnational relevance as well.

In frequent cases travellers want to plan a multimodal journey, using rail or bus, from one small village to another or to a bigger city. In less densely populated areas, public transport is often handled by an on-demand principle, such as dial-a-ride. These small-scale public transport solutions are in many cases not depicted appropriately (or not at all) in traveller information services. This raises the problem of unclear trip planning as end users have to visit several web pages or use services from single public transport operators for checking timetable and fare information. Therefore there is a demand for a better integration of demand-responsive transport into traveller information systems.

These aspects of cross-border, multimodal travel information and the integration of demand-responsive transport services are addressed by the project LinkingDanube. The approach that was chosen is a central-distributed approach (decentralised) in order to link existing, but isolated systems also across borders. LinkingDanube stands for "Linking transnational, multimodal traveller information and journey planners for environmentally-friendly mobility in the Danube Region" and is co-funded by the INTERREG Danube Transnational Program of the EU. With the proof-of-concept to be developed and demonstrated within the project, LinkingDanube will present traveller information from various local systems as one routing result to the end users via the recommended European technical specification entitled 'Intelligent Transport Systems — Public Transport — Open API for distributed journey planning 00278420'[3] elaborated by CEN/TC 278.

The main outcome of LinkingDanube will be a transnational cooperation of public and private transport operators in regard to integrated traveller information in the Danube Region. This cooperation improves organisation, efficiency and transnational interoperability of the public transport network and links mobility services in order to connect less accessible areas. Alignment between transport operators and common provision of easily accessible information will lead to improved knowledge and usage of environmentally-friendly transport modes, contributing to a more sustainable transport system.



1.2. *European legislative framework for multimodal travel information*

The concept of linking services can be considered as a subdomain of intelligent transport systems (ITS), which is defined in the ITS Directive (2010/40/EU) issued in 2010 by the European Commission as the application of information and communication technologies in the field of transport (including infrastructure, vehicles and users) and in traffic and mobility management.[4] The main elements of the Directive are the four priority areas, within a definition of six priority actions.

The priority areas are the following:

I. Optimal use of road, traffic and travel data;
II. Continuity of traffic and freight management ITS services;
III. ITS road safety and security applications;
IV. Linking the vehicle with the transport infrastructure.

The priority actions are the following:

a) The provision of EU-wide multimodal travel information services;
b) The provision of EU-wide real-time traffic information services;
c) Data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users;
d) The harmonised provision for an interoperable EU-wide eCall;
e) The provision of information services for safe and secure parking places for trucks and commercial vehicles;
f) The provision of reservation services for safe and secure parking places for trucks and commercial vehicles.

4 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:207:0001:0013:EN:PDF

In accordance with the Lisbon Treaty[5] the European Commission has the mandate to adopt specifications of functional, technical, organisational, or service provision-related nature under the ITS Directive in order to improve compatibility, interoperability, and continuity of ITS applications throughout the whole European Union. This has happened in form of Delegated Regulations supplementing this Directive, each of those for one priority action.

As the Delegated Regulation (2017/1926) with regard to the provision of EU-wide multimodal travel information services lines out, there are numerous multimodal traveller information services in Europe. Those are largely limited to their respective Member State territory, especially considering door-to-door routing. The Delegated Regulation (2017/1926) establishes the necessary specifications in order to ensure that EU-wide multimodal travel information services are accurate and available across borders. It defines rules for the accsibility, exchange and reuse of travel and traffic data and is targeted to transport authorithies, transport operators, infrastructure managers or tranport on demand service providers.

In order to overcome the existing hurdles and to enable cross-border door-to-door routing via single entry for the end user, linking services are considered as a key solution. Linking services is defined in the Delegated Regulation (2017/1926) as follows:

“Linking of service means the connection of local, regional, and national travel information systems which are interlinked via technical interfaces to provide routing results or other application programming interfaces (APIs) results based on static and/or dynamic travel and traffic information.”[6]

As for the technological tools to be used, the regulation recommends that travel information services should use the European technical specification entitled ‘Intelligent Transport Systems — Public Transport — Open API for distributed journey planning 00278420’ when performing distributed journey planning. This technical specification is outlined in more detail in **chapter 2**.

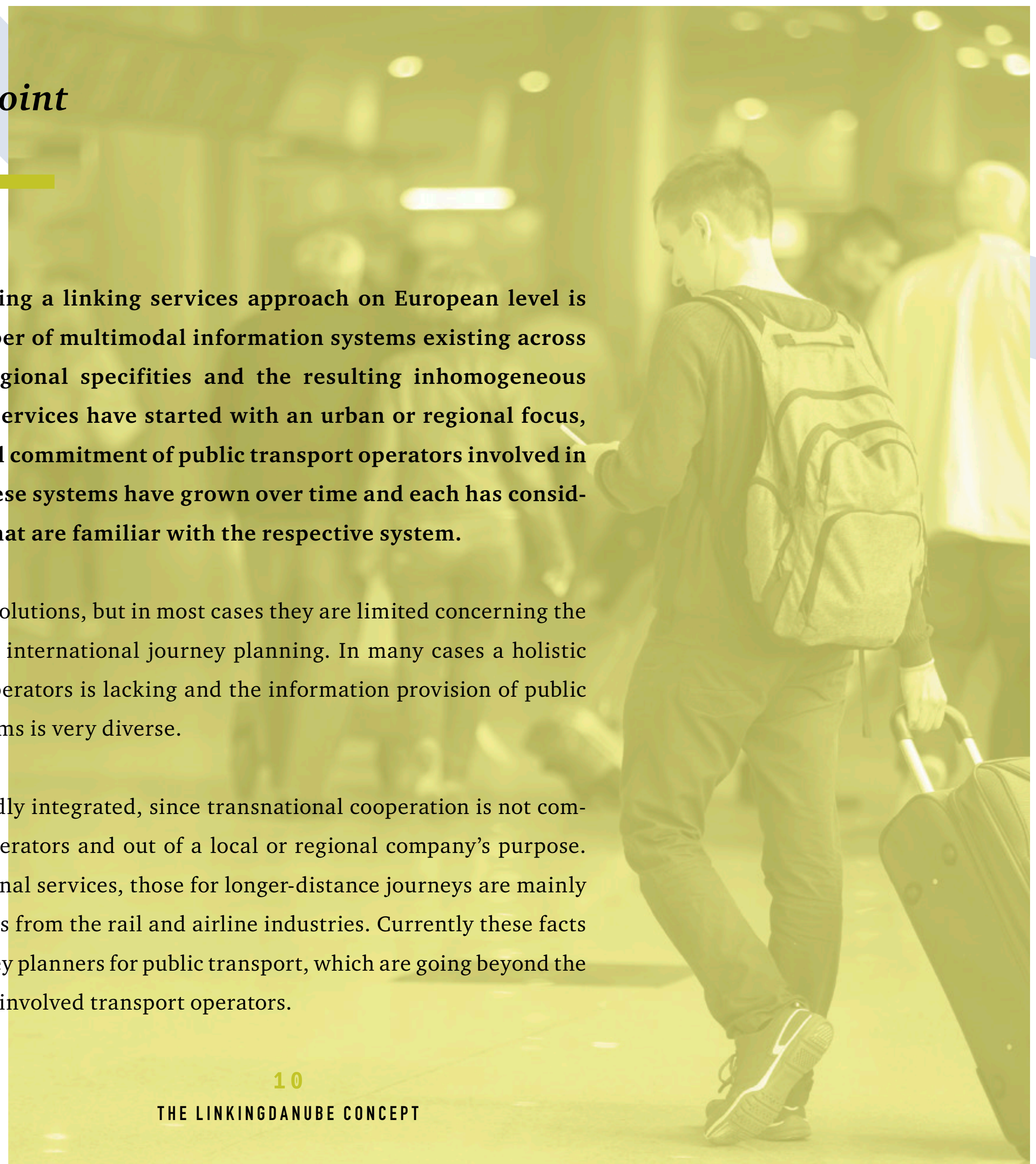
Beside of so called “scheduled” modes, like air, rail including high speed rail, conventional rail, light rail, long-distance coach, maritime including ferry, metro, tram, bus and trolley-bus, also demand-responsive modes are addressed with the Delegated Regulation (2017/1926) in regard to travel information provision. It defines demand-responsive transport as follows: *“Transport on demand means a passenger transport service which is characterised by flexible routing such as car- sharing, car-pooling, bike-sharing, ride-sharing, taxi, dial-a-ride services. These services usually require interaction between the transport on demand service provider and end-users before delivery.”*

“In order to enable cross-border door-to-door routing via single entry for the end user, ***linking services is considered a key factor.”***

5 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:12007L/TXT
6 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R1926&qid=1523344166532&from=EN

In most Danube Region countries demand-responsive transport (DRT) service provision is still at the beginning, resulting in different types of operation. Due to the highly individual character of DRT, many uncertainties remain at the provider side and its connection with other service providers (especially how they exchange information).

Looking at the Danube Region as a whole, public transport providers often operate DRT services themselves in order to minimise the loss on those lines where the service has to be provided by law, but profit cannot be realised. Therefore, these solutions are usually integrated into the public transport network. Commercial DRT services on the other hand are usually stand-alone mobility services whereas also here exceptions exist that have already established cooperation with the local public transport operators. But looking at the Danube Region, DRT services differ widely from country to country and provide different types of organisation and business models. What most of them have in common is that they mainly serve very small operation areas, which complicates the development of adequate business models.



1.3. The starting point

The starting point of developing a linking services approach on European level is represented by the huge number of multimodal information systems existing across Europe. Due national and regional specifities and the resulting inhomogeneous preconditions, most of these services have started with an urban or regional focus, depending on the coverage and commitment of public transport operators involved in the information provision. These systems have grown over time and each has considerable numbers of end users that are familiar with the respective system.

The services provide a range of solutions, but in most cases they are limited concerning the functions of multimodal and/or international journey planning. In many cases a holistic approach towards modes and operators is lacking and the information provision of public and private transportation systems is very diverse.

Cross-border information is hardly integrated, since transnational cooperation is not common between local transport operators and out of a local or regional company's purpose. In contrast to the local and regional services, those for longer-distance journeys are mainly mono-modal information systems from the rail and airline industries. Currently these facts result in a lack of seamless journey planners for public transport, which are going beyond the system boundaries of the locally involved transport operators.

7 https://www.gov.uk/government/publications/journeyweb
8 http://www.delfi.de
9 https://eu-spirit.eu

Therefore, during the past decade some systems have been introduced in order to cover wider geographical areas like JourneyWeb[7], DELFI[8] and EU-Spirit[9], but still a European-wide travel information system is lacking.

In the course of European coalescence and an increasing focus on pan-European multimodal transport, multimodal journey planning should be enabled across both geographic and systemic borders. Taking into account that there are already existing services in the Member States, there are basically two possibilities to achieve this:

1. **Creating a central single European traveller information service** by setting up data exchange and integration processes
2. **Building up a decentralised (distributed) European travel information service through linking existing local, regional or national services** without data exchange mechanisms

The figure below compares the geographic coverage provided by centralised and distributed journey planners.

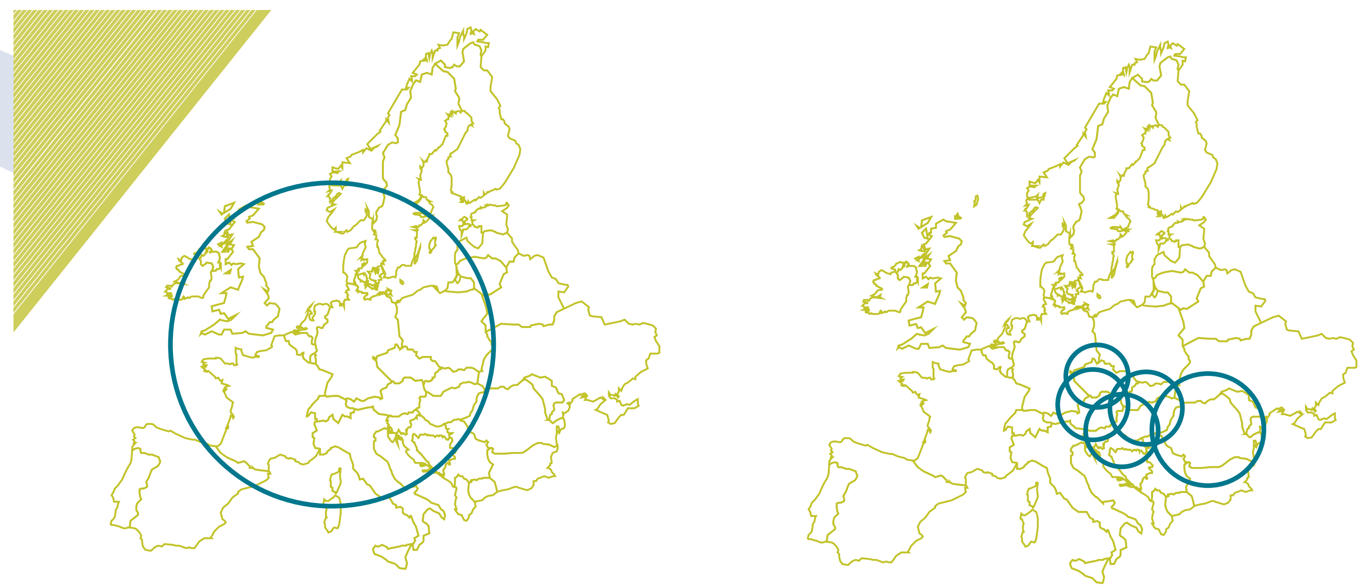


FIGURE 1 Geographic coverage provided by central (left) and distributed journey planning (right)

“[…] from the aspect of data quality and reliability **a distributed approach has a clear advantage.**”

In **a centralised approach,** all the data (e.g. stops, routes, interchanges, journeys, etc.) are uploaded into a single platform and queries run against it. The algorithm finding the best possible path is able to operate within a single shared memory space and carries out a very large number of comparisons very quickly. A central planner engine will typically comprise a cluster of servers and might cover a region many regions combined, or even the whole of Europe. A centralised approach means that data are made available by the local systems over a common format and on regular basis. In the recent past, there has also been a trend towards open government data (OGD) and open traffic data. This resulted in larger, “consolidated” data records in travel planning.

However, the information provided by these systems is less comprehensive and up-to-date than that of local or regional travel information systems, which maintain their data in the highest quality and with tight update routines. Changes in timetables or disruptions are kept highly up-to-date in local source systems only, while open traffic data are usually updated at longer intervals and mainly offer basic target data. The issue of changingtimetables and routes is particularly relevant in countries where the mobility market is being liberalised and timetable changes can be introduced much more frequently and at the estimation of the operator.

The **decentralised (distributed) system** – will require a common interface between existing traveller information services as well as the ability of participating systems to appropriately distribute requests that exceed their system boundaries and reassemble the results to one single routing result. In this way the systems can handle the relevant routing in their own environment and only exchange requests and results instead of data sets.

For the operators of travel information services, this means that cross-border exchange no longer necessarily means making one’s own data available to others via data exchange formats and processes. Providers retain sovereignty over their data and only provide a particular interface so that other systems can connect and request information (such as a route) and not the data itself. The information is provided at the same high quality and actuality level as in the local system that is maintained by tight update routines.

So from the aspect of data quality and reliability a distributed approach has a clear advantage. Besides, a study conducted on the future development for European multimodal journey planners in 2011[10] reveals that also the stakeholders prefer distributed solutions because these correspond better to existing organisational structures, facilitate adequate allocation of responsibility for data quality, and accommodate issues related to data ownership. Therefore the decentralised approach, addressed in the following as “linking services”, is favoured in this concept.

10 https://ec.europa.eu/transport/sites/transport/files/themes/its/studies/doc/2011_09-multimodal-journey-planner.pdf

1. Distributed multimodal Journey Planning for the Danube Region

1.4. *The benefits of linking services*

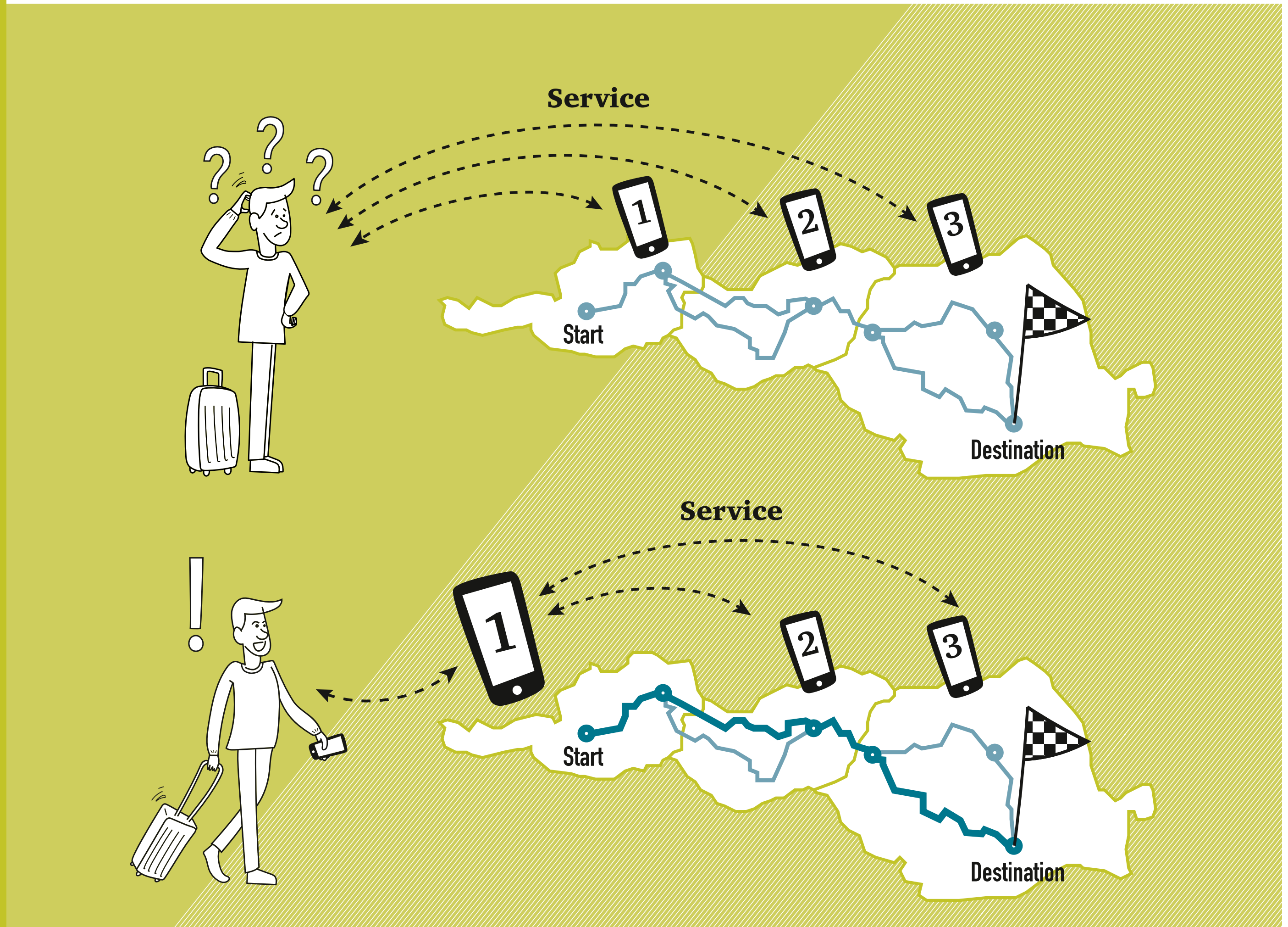
The approach of linking services in contributing to the achievement of European goals and the promotion of multimodal transport focuses on the field of cross-border traveller information.

For the operators of travel information services, this means that cross-border exchange no longer necessarily means making one's own data available to others via data exchange formats and processes. Providers retain sovereignty over their data and only provide a particular interface so that other systems can connect and request information (such as a route) and not the data itself. This is possible with a dedicated application programming interface (API). An API enables other programs to "plug-in" or connect their system to the own system. The API offers a set of clearly defined methods of communication between various systems and can be compared with a messenger that exchanges requests and answers.

For the end users linking services mean that they can request trip information through the application that they are used to, but they will receive results of increased coverage and functionality since the API – the messenger – works in the background and gathers information from other systems as depicted in FIGURE 2.

In addition, it also brings benefits for the traveller, as access to travel information becomes essentially easier and more convenient, in particular when travelling across borders. In this way end users can triple their benefits without having to consult three different systems.

FIGURE 2: The concept of linking services – simplify journey planning for end users



By linking several traveller information systems, the coverage of one service is being increased to the area covered by all of the systems. In case of a routing request across three different regions, such a request will be split in accordance with the geographic coverage of each of the three systems. The services will then calculate their part of the routing and hand back the result to the enquiring entity which assembles the results and presents an overall result to the end user as shown in FIGURE 3.

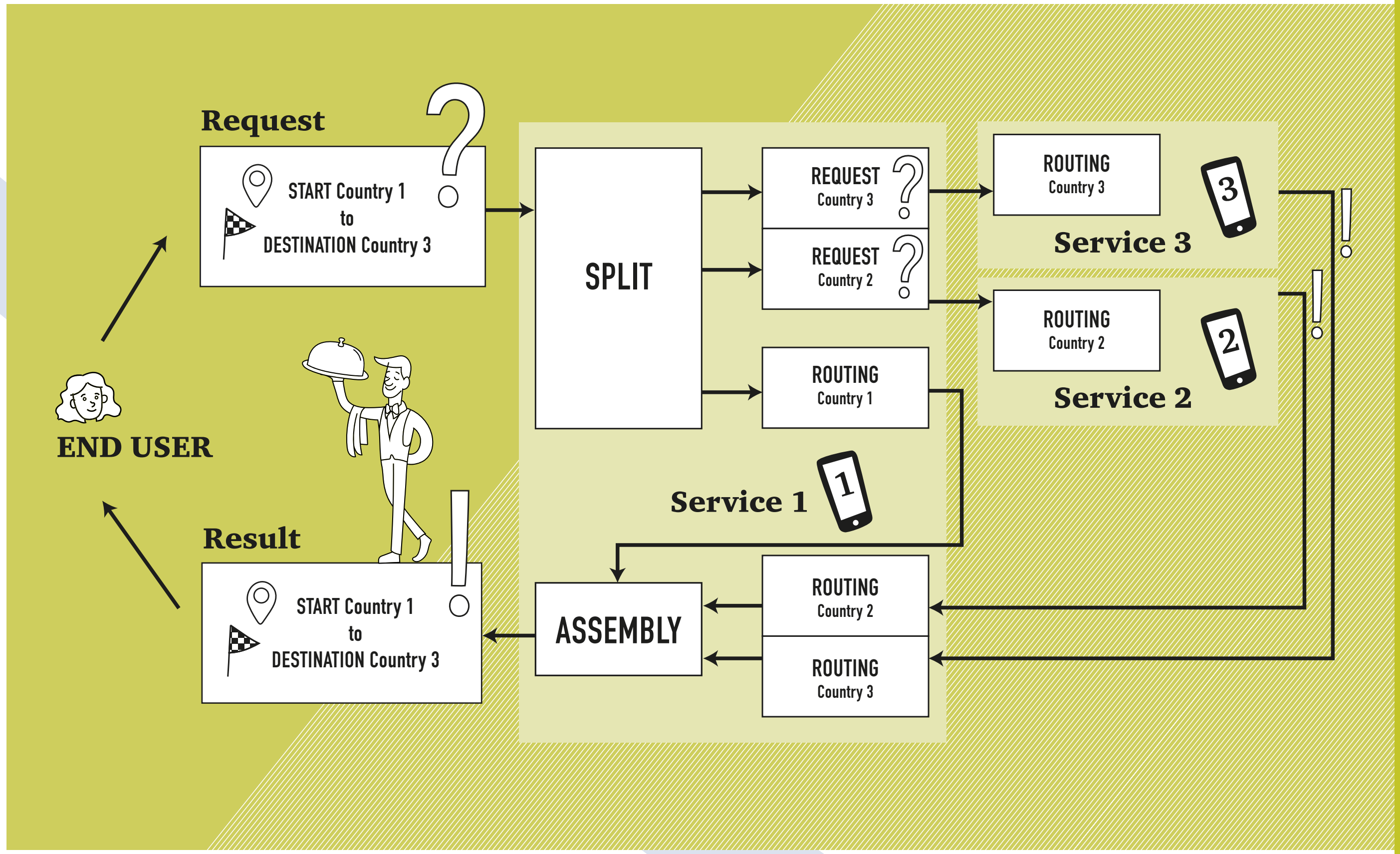


FIGURE 3: The concept of linking services – split of requests and assembly of results

At the same time there is no need for data exchange since all the routing logic and corresponding data will stay within the respective system boundaries, making it more efficient and sustainable. As long as the enquiring system knows how to split a cross-border request and to which other systems the partial requests must be distributed to, one comprehensive and high-quality routing result can be created from using the intelligence of many.

1.5. The way forward

1.5.1 BUILDING ON EXISTING SERVICES

Closing down well-established systems in favour of a new and bigger solution would not only most likely be boycotted by the operators of these services, it would also be most counter-productive from the viewpoint of building up and maintaining user communities. Instead it seems more sensible to improve and extend the features of an existing service and therefore not only achieve relevance through current users, but also to attract new users with improved features and the extended area for which travel information is available.

That way, easier access to public transport information and alternative modes of transport, the awareness and acceptance of such sustainable mobility options improve. Awareness and acceptance are key factors for a change in mobility behaviour towards a more environmentally-friendly transport. In this way the contribution of European goals on emission reduction can be pursued very efficiently

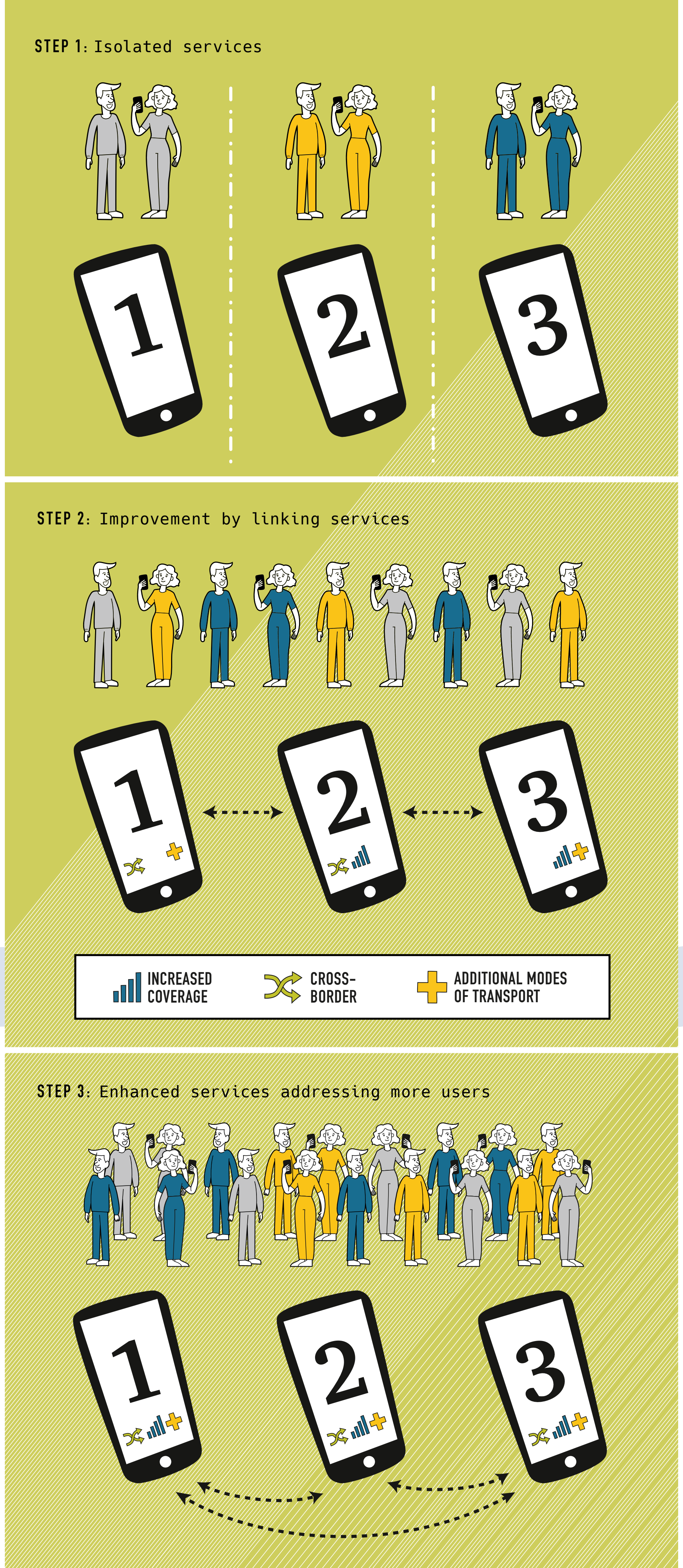


FIGURE 4: The benefit of linking existing services

1.5.2 DEMAND-RESPONSIVE TRANSPORT – SUPPLEMENTING EXISTING SERVICES

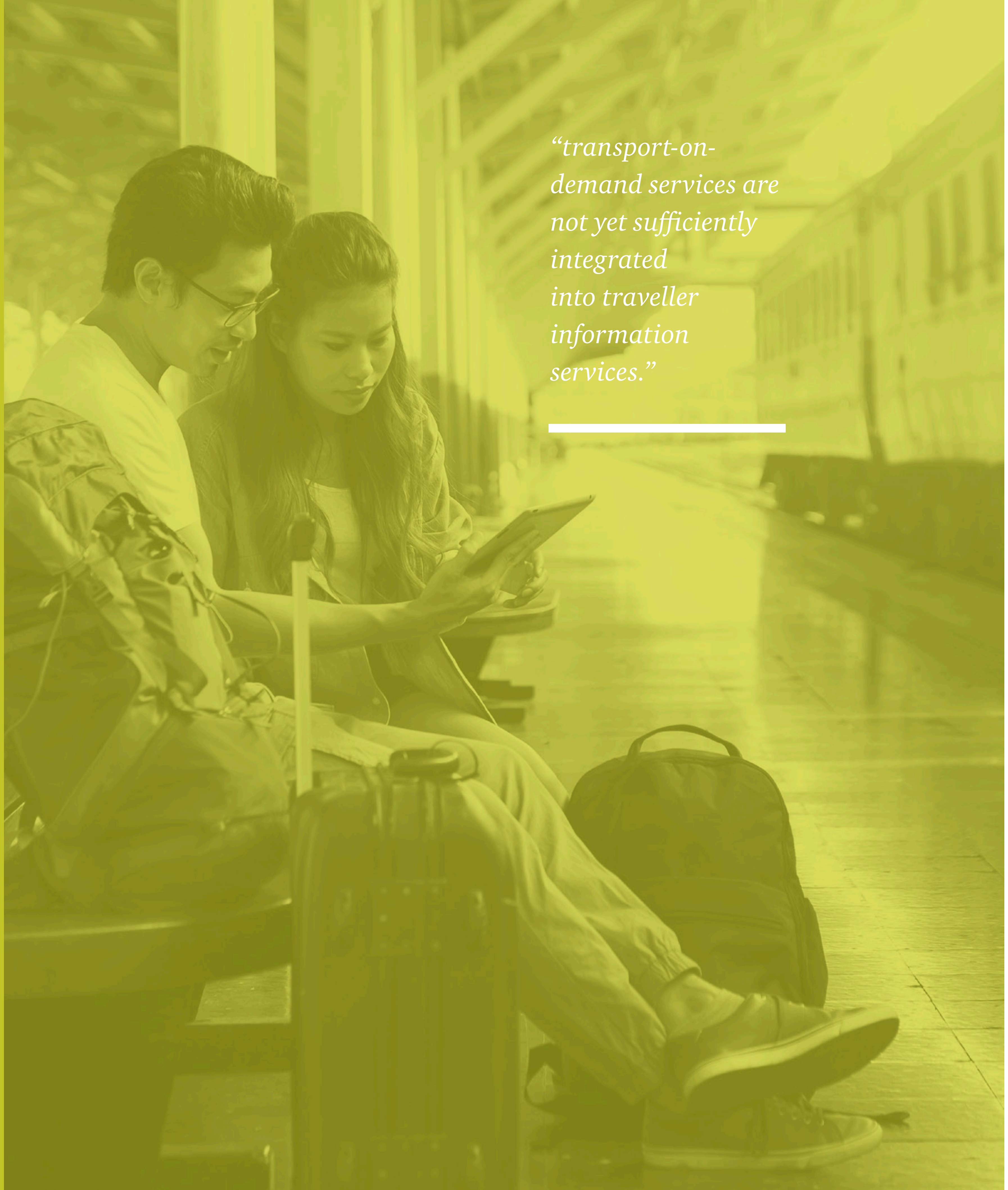
Public transport plays an essential role in providing accessibility and countering problems related to social exclusion. The need for an appropriate public transport network is unquestionable. Suitable transport alternatives should be available for everyone at a fair price in order to be able to fulfil transport demand. However, regular public transport services – such as regular bus services – cannot always meet the most desirable requirements for all situations. This is particularly the case in less densely populated areas where demand is low and widely dispersed.[11]

On demand transport or demand-responsive transport (DRT) is a transport operation mode with vehicles serving flexible timetables and/or flexible routes in line with end user needs.

Passengers must indicate their travel demand to the operator or to the driver. Usually providers only serve upon request, often combining more trips of independent passengers within the same journey. This results in a transport service that offers some degree of flexibility to the passengers with flexible routes and/or flexible timetables.

The public transport companies examined the provision of DRT services applying the same business model as for traditional public transport lines. Revenues are generated from passenger fees, municipal and state support. Private companies can operate with no public subsidy, fares cover expenses. In some cases (e.g. in Austria) private companies are contracted by regional or local governments or at least get some public funding (either from national, regional or local funds).

11 TE MORSCHE W.J. (2017): The potential of Alternative Transport Services: an exploration of the potential and the factors influencing the potential of Alternative Transport Services in the province of Overijssel, available at http://essay.utwente.nl/72468/



"transport-on-demand services are not yet sufficiently integrated into traveller information services."

As for funding, DRT schemes may be fully or partially funded by the local transit authority, as providers of socially necessary transport. As such, operators of DRT schemes may be selected by public tendering. Other schemes may be partially or fully self-funded. DRT schemes may also be provided by private companies for commercial reasons. Some conventional bus operating companies have set up DRT-style airport bus services, which compete with larger private hire airport shuttle companies. Accordingly, organisational options of DRT integration must be prepared in details as a part of the future organisational and operational regulation.

As for DRT services, some already offer web-based and app-based travel information and booking for their own service, however the service is not or not sufficiently integrated into multi-modal travel information systems. Therefore a complete intermodal or multimodal door-to-door route including demand-responsive transport cannot be provided to the user or not in a sufficient manner.

There are some examples how integration can look like, but in general the full integration is missing and the focus is on static information on the website of the operators and some static information included in the journey planner of the concerned region.

The main aspect in regard to information provision is that transport-on-demand services are not yet sufficiently integrated into traveller information services. A key element for the success of any DRT service is the information about the service itself and the method to apply it, including that travel demand must be generated at the starting phase of a given demand-responsive service. Travellers' behaviour generally appears to be relatively inelastic. When people are thinking about transport, they have basically two traveling modes in mind: public transport with fixed schedule or private cars. Hence, if users can be informed directly about transport-on-demand services as a travel mode option within existing traveller information services (e.g. on a website or via app), DRT services hold the potential to be preferred to private car usage. Integrating transport-on-demand into existing and well-established journey planning services could bring added value for both DRT services and the journey planner itself. The integrated use should be elaborated in the future so that demand-responsive services can be booked through an integrated interface.

Depending on the design and configuration of the service, DRT also requires some flexibility from passengers since it is not always possible to start and end the trip to at a pre-defined time and place. In such cases passengers get a time-window both for the departure and the arrival. Early planning and booking of trips significantly increases usability of DRT transport.

The best possible information about integrating demand -responsive transport services is particularly important in order to encourage the shift towards more environmentally aware mobility behaviour. Only through an attractive strategy and the sufficient availability of transport resources can end users be convinced of the advantages of multi-modal respectively public transport solutions.

1.6. *The potential impact and vision of linking services*

Linking services in the frame of a cental-distributed apporach has potential impact and benefits on different levels – for the traveller, the local operator and the EU-wide availability of continous travel information, as described in chapter 1.4.

For the end users linking services mean that they can request trip information through one single application that they are used to, but they will receive results of increased coverage and functionality since the API – the messenger – works in the background and gathers information from other systems.

By linking several traveller information systems, the coverage of one service is being increased to the area covered by all of the systems. In case of a routing request across three different regions, such a request will be split in accordance with the geographic coverage of each of the three systems. The services will then calculate their part of the routing and hand back the result to the enquiring entity which assembles the results and presents an overall result to the end user. Without that linked approach the user would have to consult different travel information services and put together the results by him- or herself. As explained in FIGURE 2, end users can triple their benefits without having to consult three different systems.

At the same time there is no need for data exchange since all the routing logic and corresponding data will stay within the respective system boundaries, making it more efficient and sustainable. As long as the enquiring system knows how to split a cross-border request and to which other systems the partial requests must be distributed to, one comprehensive and high-quality routing result can be created from using the intelligence of many.

For the operators of travel information services, this means they will retain sovereignty over their data and only provide a particular interface. They will be able to extend the coverage of their own local service by using the information of other systems and so retain their market position or even improve it.

THIS LEADS TO THE FOLLOWING VISION FOR LINKING SERVICES IN THE COURSE OF LINKINGDANUBE:

- **LinkingDanube will extend the coverage of traveller information services across borders for both cities and rural areas in the Danube Region.**
- **By linking existing services via Open API, LinkingDanube will retain the relevance of these services, facilitate the accessibility of travel information and thus the comfort in obtaining information for the end user and foster the use of sustainable transport modes.**

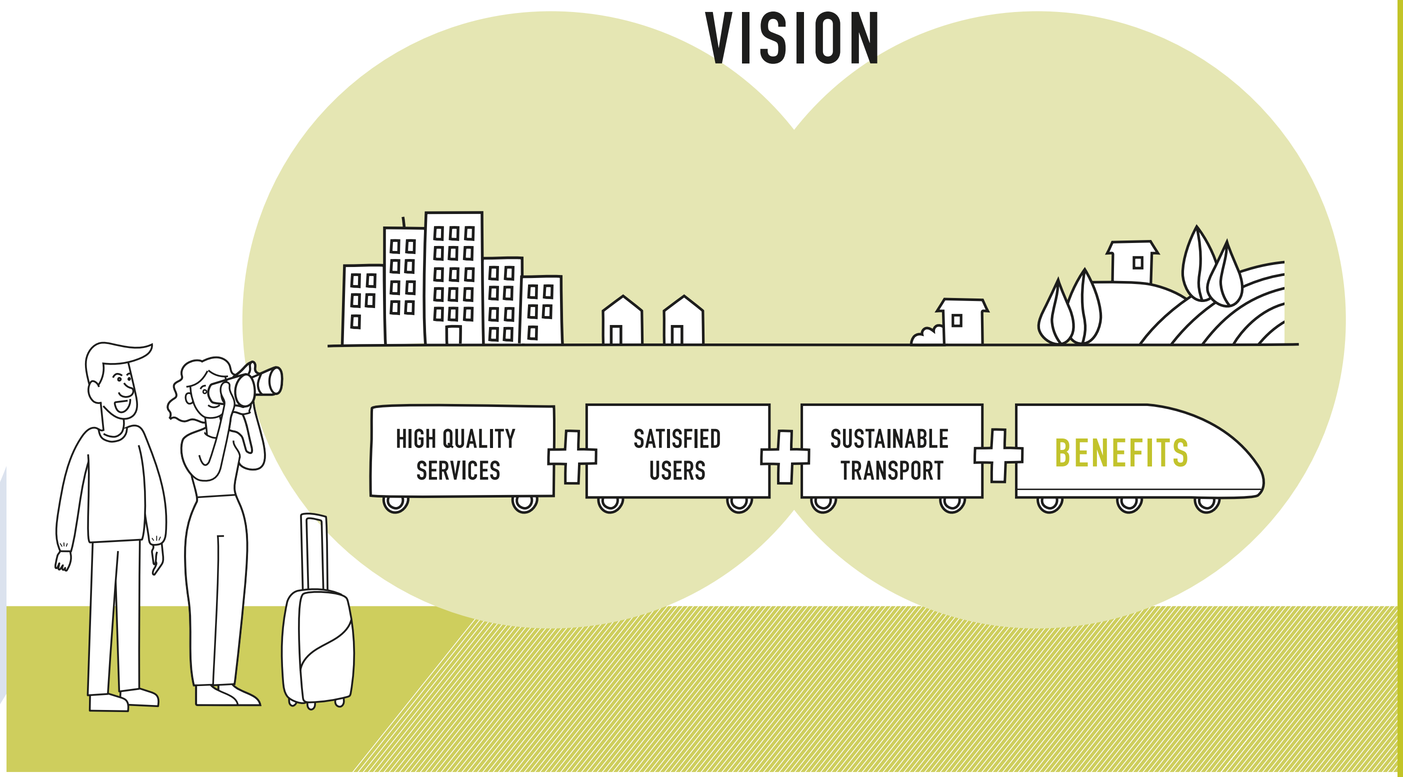


FIGURE 5: The LinkingDanube vision for cities and rural areas

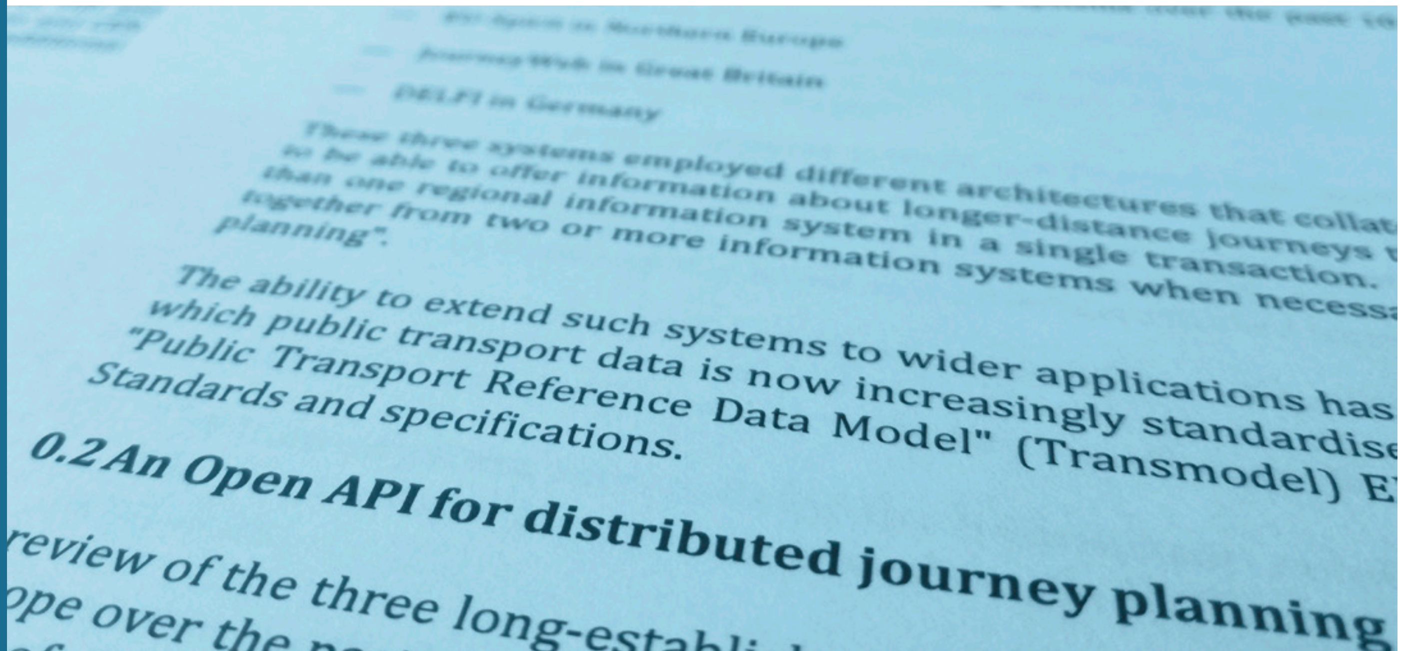
Furthermore the mutual learning on operator side in a transnational manner leads to increased organisational and operational capacity within the organisations to tackle cross-border topics and take macro-regional concerns into account above from purely national issues. Coordination between stakeholders in the Danube Region will facilitate efficient integrated planning and a better organisation of public transport links, improving the network through well-aligned measures. An agreed transnational concept could be the basis for intensified transnational cooperation of the (public) transport service providers in the Danube Region in the future.

This close cooperation of service providers in terms of information provision will lead to a better alignment of schedules and connections in a next step. The resulting improved capability of existing traveller information services would be consistent with the increase of the continuity of services required by the ITS Directive (2010/40/EU) and encourage a sustainable shift from individual transport towards multimodal and public transport-driven mobility according to the principle of "supply creates demand".

2. OPEN API FOR DISTRIBUTED JOURNEY PLANNING

A CEN technical specification called "Public transport – Open API for distributed journey planning" has recently been developed by the Technical Committee CEN/TC 278 in order to facilitate distributed journey planning for public transport, which opens the way for a unified and standardised solution in Europe. This so called Open Journey Planning API (OJP) enables a system to provide just one interface that can be made available widely (to authorised users or openly) rather than having to engineer separate APIs for each exchange arrangement that may be required with other systems. The technical specification can be considered as an important basis of all work related to implementing distributed journey planning, so also within LinkingDanube.

The following chapters provide a brief introduction into the basic concept of the specification.



2.1. Open Journey Planner API

API is the acronym for application programming interface, which is a software intermediary that allows two applications to talk to each other. Each time people use an app for social media, to book a flight, to make a hotel reservation, send an instant message or check the weather, APIs are used. API can be regarded as a messenger that allows communication between different systems. It takes over the user request and sends data to a server. The server then retrieves that data, interprets it, performs the necessary actions and sends it back to the requesting system over the API.

In many domains, like social media and e-commerce, APIs are well known and operated on daily basis. Also in the travel information domain APIs are already used for the purpose of information gathering. However up to now propriety APIs have been applied, leading to a high diversity of APIs. Therefore there was a need for an Open API that provides an opportunity for just one universal channel to exchange information.

The technical specification defines a schema for establishing an Open API for distributed journey planning that can be implemented by any local, regional or national journey planning system in order to exchange journey planning information with any other participating local, regional or national journey planning system. The principle of Open API is underpinned by the main existing standards for public transport operations, i.e. IFOPT[12] (Identification of Fixed Objects in Public Transport), NeTEx[13] (Network and Timetable Exchange), SIRI[14] (Service Interface for Real-time Information) and Transmodel (Public Transport Reference Data Model).

Applying an Open API facilitates distributed journey planning, if more than one home system is used to create a transnational route. If different routing systems between Member States are to be connected for transnational request handling and routing, the API needs to know all modes of transport that are supported, all information about lines and stops as well as the minimum requests to be processed by each of the different home systems, including the (possibly dynamic) hubs for transnational handover of the request.

Practically the planning procedure is distributed into several planning processes. First the client system sends a TripRequest message to its enquirer home system. The home system forwards this request to the Distributed Journey Planner (DJP) system. The DJP has the ability to split the journey planning request into pieces and to find the relevant home systems (local journey planning engine). The responding home systems may get more than one request before the total trip is completely calculated.

12 http://www.transmodel-cen.eu/standards/ifopt/
13 http://netex-cen.eu/
14 http://www.transmodel-cen.eu/standards/siri/

The Open API technical specification supports different modes of transport (simple types) namely line-based public transport, individual modes as well as private and continuous modes. The latter two include modes offered by private persons (e.g. car-pooling) and services that run on any time, without a timetable. This is a clear reference to demand-responsive transport and shows its relevance as well as the interplay with the concept of linking services.

Consequently, demand-responsive transport modes and also shared mobility options can be integrated using the Open Journey Planning API (OJP). According to the Open API technical specification, DRT services are defined as a continuous service operational at any time and without a timetable. This continuous mode is integrated at the same hierarchy as other modes of transport. However there are particular details necessary for DRT service integration. These details include information about the operative status of the service, but also description of the route (for example from airport to city centre), the service origin (first stop) and destination (last stop) and service via-points (for example public transport stops). Also information on the vehicles type and facilities is provided as well as booking information for the service.

DRT services and shared mobility options can be embedded at the same level as the public transport modes and individual modes and hence can be integrated into routing and information provision.

2.2. *System architecture(s) for distributed journey planning*

Distributed journey planning requires the interplay of numerous entities in a rather complex environment. The main principle includes splitting a big task – a trip request that exceeds the boundaries of one journey planner – into a set of smaller tasks that can each be processed by several Local Journey Planners and afterwards be reassembled and presented as one single routing result. Independent of its setup details, the splitting and reassembling has to be handled by a distributing system while the sub-tasks are being handled by responding systems.

The Open API technical specification outlines some working assumptions for a distributed journey planning approach:

1. The distributing system is able to split the original task into sensible sub-tasks.
2. The distributing system knows from which responding systems reasonable solutions for a sub-task can be expected.
3. The distributing system knows the exchange points (and their identifiers) that will link the parts of the overall trip (the solutions of each responding system for a sub-task).

Points 1 and 2 above emphasise the consequent necessity of knowing the coverage of each responding system in terms of area and transport services. For any distributed journey planning environment there are two basic questions to be asked for each enquiry:

- Can the enquiry be answered by using only information which is already available in the present system? If yes, then distributed planning is not required.
- If distributed journey planning is required, which other journey planning systems can provide the components to make up the journey plan solution?

In further consequence, it depends on the exact system architecture in order to determine which entities within the system have to deal with those questions to what extent. There are basically two versions of a system architecture for linking services: the **central-distributed** and the **completely-distributed (peer-to-peer)** approach.[15]

15 https://ec.europa.eu/transport/sites/transport/files/themes/its/consultations/doc/2015-its-mmtips/consultation-report.pdf

2. Open API for Distributed Journey Planning

In the **completely-distributed approach** a network of journey planners collaborate to compute journeys over a wide area. A first planner computes the journeys from the origin to a number of exchange points and then asks a second journey planner to compute journeys from those exchange handover points to the destination point. In this concept each journey planner must have a shared data set of exchange points, and furthermore know with which additional planner it should connect for journeys covering a particular area (typically via a shared API). In this architecture both communication and enquiry process work on a peer-to-peer decentralised basis.

In a **central-distributed journey planning system** one of the participating systems takes on more responsibilities on behalf of the other systems. This central entity can hold supporting data and has more responsibility in the facilitation of the communication between the systems. That means that some journey planners do not itself undertake the distributed journey planning. Instead these systems pass this task to a central entity which completes the process and returns their answers to the journey planners system. Despite the fact that supporting data and communication is more centralised then in the meshwise architecture, the core travel data are kept at the local home systems, so the journey planning system still is a decentralised one. An important key consideration for designing a distributed journey planning system is to define what supporting data (metadata) is required and where it is to be held. A local journey planner needs to be able to somehow recognise that a requested origin or destination is not in its own geographical area. Once this has been dealt with, it also needs to know about which system(s) will be able to provide correct answers for an enquiry going beyond the own system boundaries.

One way of managing this would be a network of Local Journey Planners that share a central repository of gazetteers (i.e. indexes of geographical entities – localities, addresses, stops & stations, etc.) in order to resolve these questions thus creating a central-distributed approach as displayed in FIGURE 6. This enables the necessary enquiries to be made within the relevant journey planning system boundaries before handing back the information to the originating home system. Alternatively each participating system could hold gazetteer data for all the participating systems' areas and the enquiry process could then work on a peer-to-peer decentralised basis thus creating a fully distributed approach.

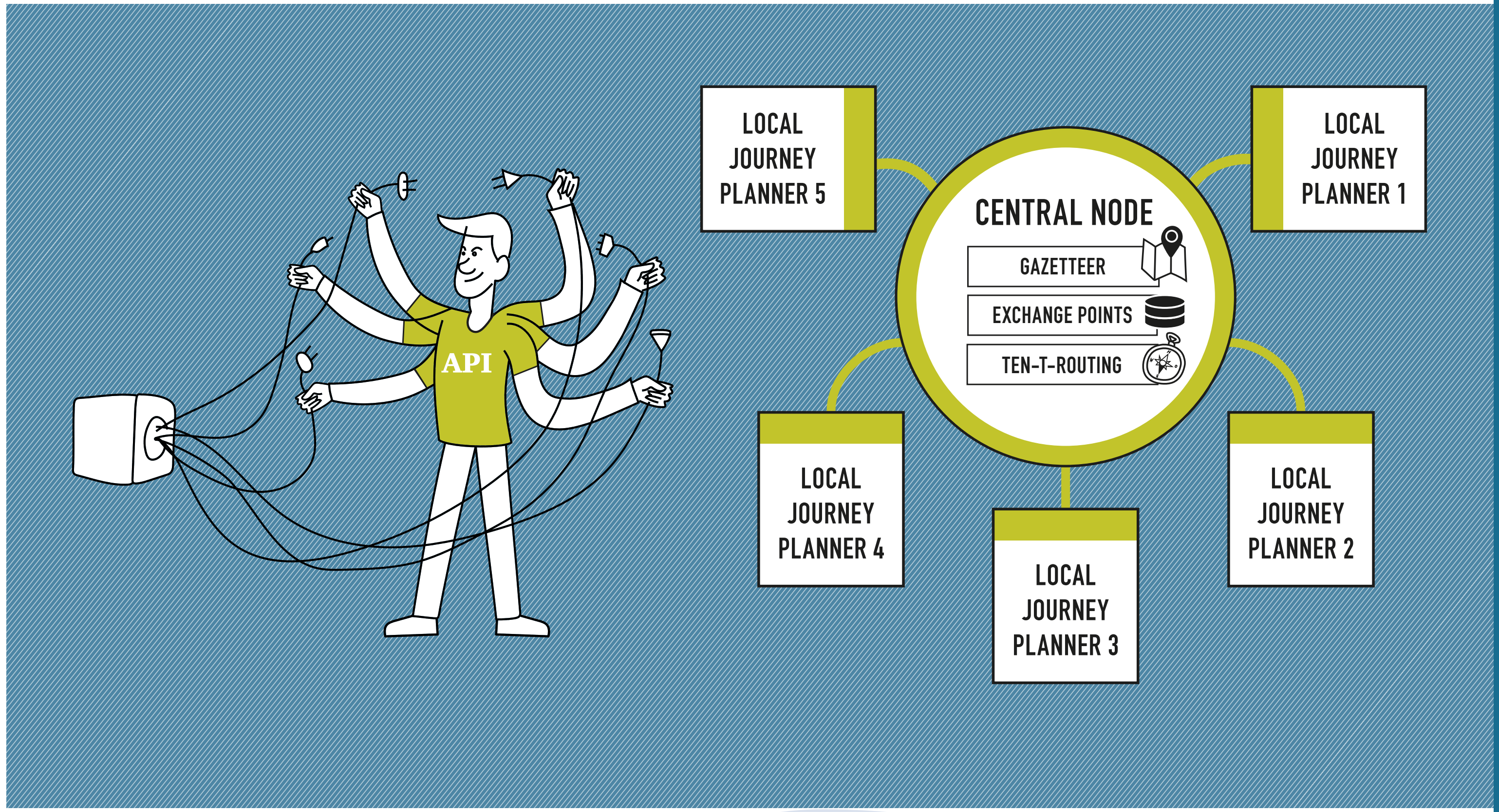
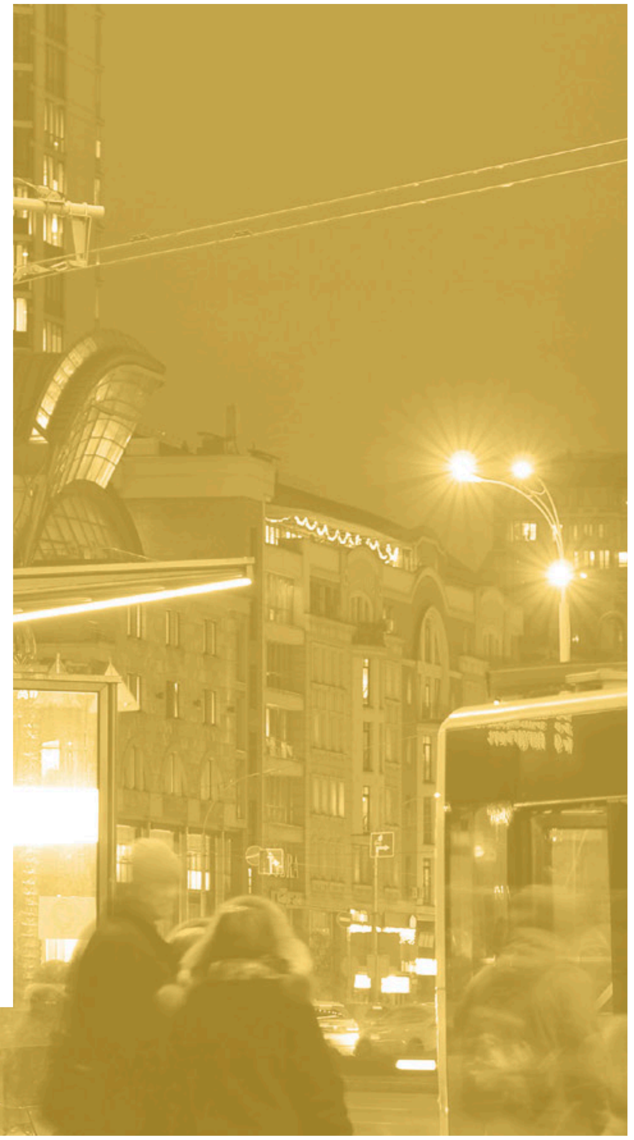


FIGURE 6: Scheme of a central-distributed journey planning architecture

In LinkingDanube the central-distributed journey planning approach was chosen (FIGURE 6). A detailed introduction of how distributed journey planning can be set up in an actual operative environment of several traveller information service operators is provided in chapter 3 of this document, demonstrated on the example of the project LinkingDanube.

3. CENTRAL-DISTRIBUTED JOURNEY PLANNING WITHIN LINKING DANUBE



Following the vision of linking existing traveller information services through Open API for improved end user experience in journey planning and European added-value in sustainability and multimodality of transport, this part of the document will show how the distributed journey planning approach has been set up in the project LinkingDanube.

The project environment also reveals the limitations that had to be faced: Although the LinkingDanube solution will be operative and accessible for end users, the limitation of time and budget given by a project structure do not allow for a comprehensive service encompassing the whole Danube Region. Rather it is a pilot realisation aiming to ensure a proof-of-concept that demonstrates the feasibility and scalability of the linking services approach.

3.1. *Local Journey Planners (LJPs) and project use cases*

16 http://www.interreg-danube.eu/approved-projects/linking-danube

LinkingDanube[16] encompasses six European Member States located in the Danube Region: Austria, Czech Republic, Hungary, Romania, Slovakia and Slovenia. One Local Journey Planner (LJP) was picked for each participating country from the variable number of journey planning services that are available to the end users in total. Some services cover only a certain region while others have national or even cross-border coverage in their routing capabilities. Differences also exist in terms of the modes of transport the LJPs are able to handle, ranging from real multimodality to mere public transport or rail only.

The following Local Journey Planners will be part of the system architecture:

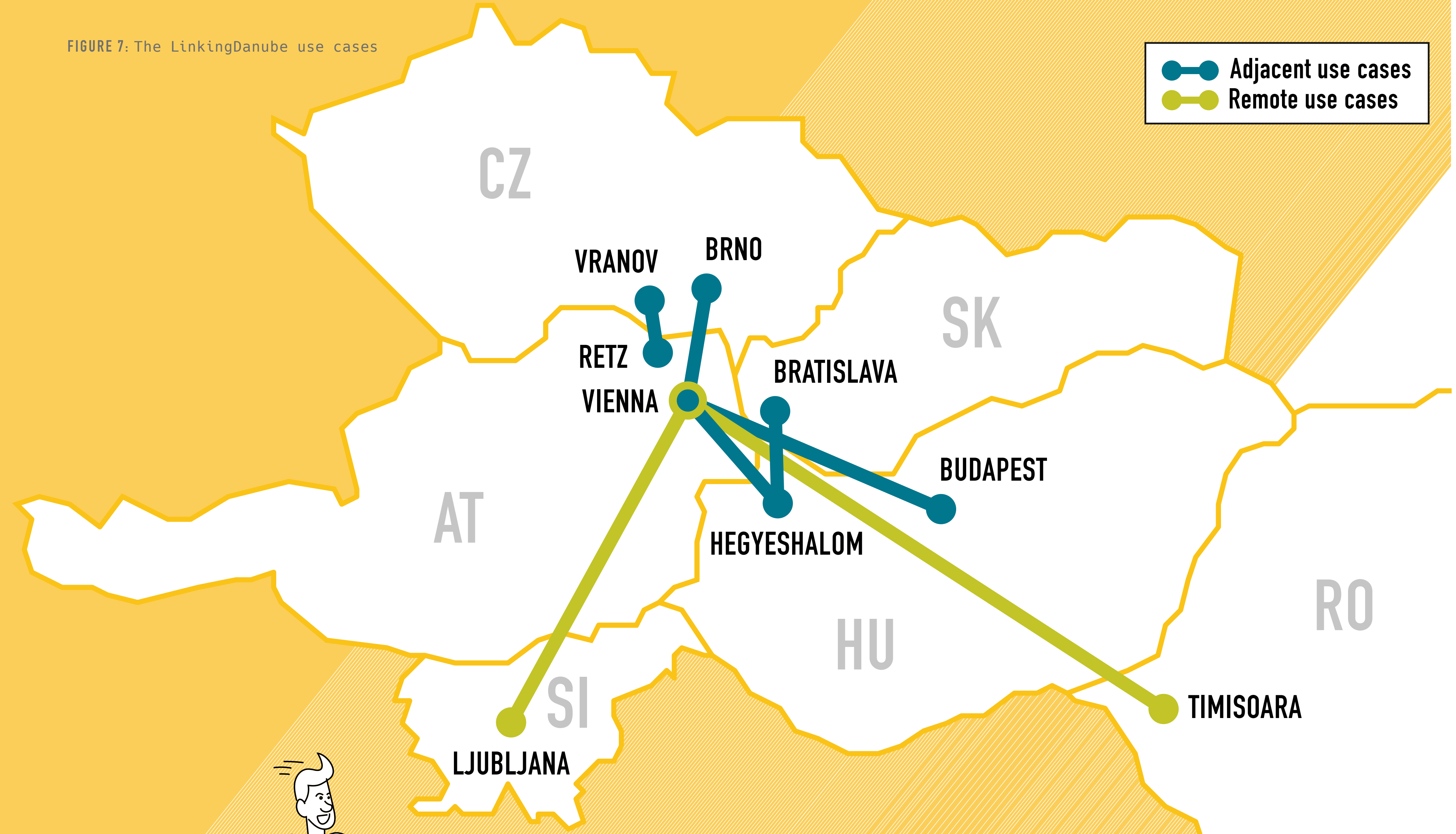
- Verkehrsauskunft Österreich (VAO) – Austria
- IDOS – Czech Republic
- Útvonalterv – Hungary
- Timisoara Journey Planner (TJP) – Romania
- iKVC – Slovakia
- AtoB Ljubljana (AtoB LJ) – Slovenia

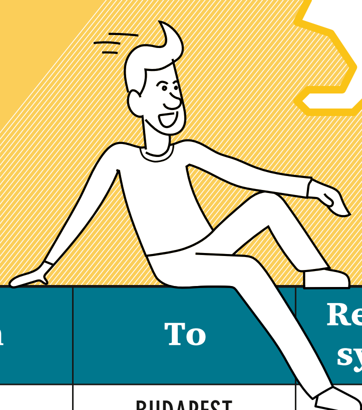
With the services selected, the work on actually linking them for the exchange of routing results can be started. Naturally the pilot action will not be able to cover the whole system landscape, as is not its purpose. So based on the initial situation and also technical parameters of the selected Local Journey Planners, a set of use cases was defined which are of major importance and suitable for achieving convincing and scalable results. In this way, the LinkingDanube pilot will create a continuous and transnational operative environment, in which the partners can demonstrate the feasibility of specific use cases for multimodal traveller information and demand transport integration.

There will be two main types of use cases for linking services as shown in FIGURE 7, which will be the **remote** (linking two services that **do not share a common border,** displayed in TABLE 1) on the one hand and the adjacent (linking two services that **share a common border,** displayed in TABLE 2) on the other hand.

The following map shows all the participating Local Journey Planners, the geographical coverage as well as the modes of transport they can handle. Furthermore it displays the project use cases that are deemed most representative for a cross border linking of services.

FIGURE 7: The LinkingDanube use cases





ADJACENT USE CASES

From	To	Required systems
VIENNA (Address/POI)	BUDAPEST (Address/POI)	VAO Utvonalterv
VIENNA (Address/POI)	BRNO (Address/POI)	VAO, IDOS
RETZ (AT) (Address)	VRANOV (CZ) (Address)	VAO, IDOS
HEGYESHALOM (Address/POI)	VIENNA (Address/POI)	VAO Utvonalterv
HEGYESHALOM (Address/POI)	BRATISLAVA (Train Station)	iKVC Utvonalterv

TABLE 2

REMOTE USE CASES

From	To	Required systems
VIENNA (Address/POI)	LJUBLJANA (Address/POI)	VAO, IRS AtoB LJ
TIMISOARA (Address/POI)	VIENNA (Address/POI)	VAO, IRS TJP

TABLE 1

LINKINGDANUBE USE CASES

Participating Journey Planners – in a nutshell

VERKEHRSAUSKUNFT ÖSTERREICH (VAO)

URL of service	www.verkehrsauskunft.at
Type of traveller information service	Multimodal – ALL transportation models (road, PT, walking, bicycle, train)
	Public transportation timetable information
	Railway service
	Coach service
	Car service
Coverage	National
	Cross-boarder on selected main routes

IDOS

URL of service	www.idos.cz
Type of traveller information service	Public transportation timetable information
	Railway service
	Coach service
Coverage	National
	Cross-boarder

UTVONALTERV

URL of service	www.utvonalterv.hu
Type of traveller information service	Multimodal – at least two transport modes
	Public transportation timetable information
	Railway service
Coverage	National

TIMISOARA JOURNEY PLANNER (TJP)

URL of service	Not yet public
Type of traveller information service	Multimodal – at least two transport modes
	Public transportation timetable information
	Railway service
Coverage	Regional

IKVC

URL of service	ikvc.slovakrail.sk
Type of traveller information service	Single Mode – only public transport OR road OR bycyle OR train OR ect.
	Public transportation timetable information
	Railway service
Coverage	Regional
	Cross-boarder

ATOB LJUBLIANA (ATOB LJ)

URL of service	www.atob.si
Type of traveller information service	Multimodal – at least two transport modes
	Public transportation timetable information
	Coach service
Coverage	Local

3.2. Minimum content specification

Prior to the implementation phase, an internal survey was carried out among the providers of the participating Local Journey Planners. This helped to verify the project use cases and display the capabilities of the single participating Local Journey Planners in terms of dealing with certain requests. This included if and to what extent the systems were able to handle routing requests based on stops, addresses, "Points of Interest" (POIs) and coordinates, which modes of transport they can cover and what quality level they can ensure.

"The focus was explicitly on the ***current capabilities of each system."***

The focus was explicitly on the current capabilities of each system. From the inputs received and discussed, aggregations have been made in order to display a common minimum of features that can currently be fulfilled by each of the local systems. When mapped against the project use cases it became visible that all of them are feasible as they were defined in the earlier phase of the project.

The resulting minimum content specification[17] defines those requests and content types that will be used within the LinkingDanube pilot demonstrations and need to be made available by each of the Local Journey Planners as a basic requirement. Although the Open API technical specification will be completely implemented by each of the Local Journey Planners, the minimum content provides information on the exchanged requests and content. Each Local Journey Planner needs to develop a translation tool in order to provide the minimum content according to Open API technical specification.

17 Please refer to www.interreg-danube.eu/approved-projects/linking-danube for contact details if you want to work with the technical specifications elaborated in the project.

3.3. The LinkingDanube system architecture

The system architecture to be followed in LinkingDanube closely relates to the concept of a central-distributed journey planner that is described in the final draft version of the technical specification "Public Transport – Open API for Distributed Journey Planning" which has been prepared by the Technical Committee CEN/TC 278 (2017). It consists of one central entity containing the major part of the intelligence and a set of distributed (i.e. decentralised) national journey planners.

In this way the LinkingDanube system – henceforth called **Danube Region Journey Planner (DRJP)** – aims to become a link between existing national journey planners and to rely on the information that those provide in order to offer extended trip planning solutions going beyond the coverage of any single local journey planner. The Danube Region Journey Planner is connected to a web service via Open API interface, which allows sending back the combined routing result to the linked local systems. The common Open API interface will be integrated into the Local Journey Planners in order to exploit the full functionality of the DRJP.

The main entities within the whole DRJP environment are the **Central Node (CN),** providing the necessary logic to manage the request and the **International Routing Service (IRS),** which is needed to generate routes between remote coverage areas of different Local Journey Planners (meaning that they do not share a common border). With this setup, the DRJP represents the link between the **Local Journey Planners (LJPs).**

The components of the system are described more in detail below.

3.3.1 CENTRAL NODE

This is the main component of the Danube Region Journey Planner. It provides the necessary logic to exchange enquiries with the Local Journey Planners and the International Routing Service, using a common communication API (Open API) and concatenates the received information to obtain the requested cross-border trip solutions. This central node offers a web portal that implements a unified graphical user interface (GUI) for transnational journey planning. An open standard map is used to visualise the final results of the multimodal trip alternatives. In addition, the central node offers a web service that implements the common API, which can be used by any other local journey planner for transnational and multimodal planning.

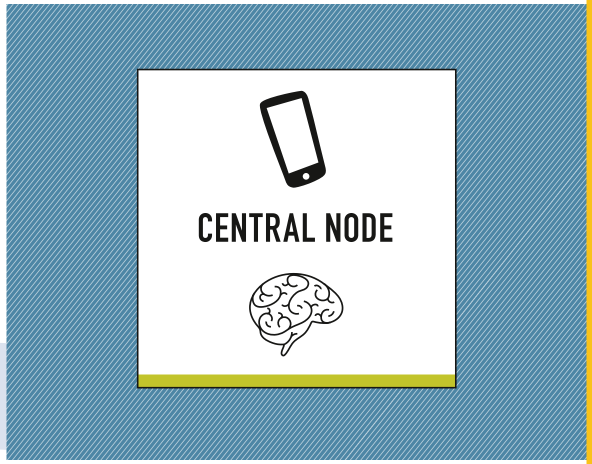


FIGURE 8: Central node

3.3.2 INTERNATIONAL ROUTING SERVICE (IRS)

This entity offers information about relevant international hubs between the origin and destination of a planned trip and static routing solutions between these hubs. In case of two adjacent (i.e. sharing a common border) services, the IRS will cover the routing between the relevant exchange points from the list of static solutions. In case the local systems do not share a common border (i.e. remote), the routing between the relevant exchange points will be calculated by this entity.

The central node and the International Routing Service together form the Danube Region Journey Planner (DRJP).

In case local systems are overlapping, the system with extended coverage could cover the routing between the exchange points without the necessity to involve the IRS (this is a requirement for the Local Journey Planners).

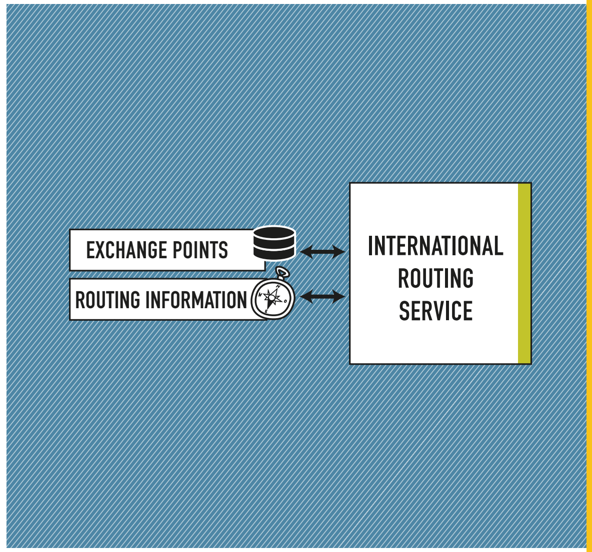


FIGURE 9: International routing service

Further function: The IRS requests actual exchange points/hubs from local routing systems directly (ExchangepointRequest). In regard to the upscaling of the system, this function is needed to evolve to a more distributed system, also in terms of exchange points. The precondition is that local routing system(s) could provide necessary data and supports ExchangepointRequest from the Open API.

3.3.3 LOCAL JOURNEY PLANNERS (LJPS)

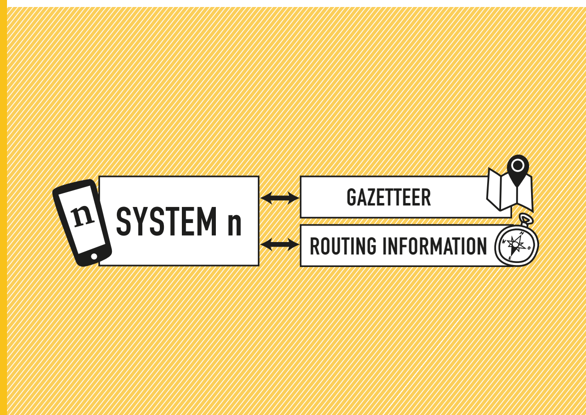


FIGURE 10: Local journey planner

These are systems with limited spatial planning ability that serve for regional or country wide trip planning. They have already implemented a web portal that offers routing in the region they are designated for. By making use of the central node web service (and possibly displaying the extended cross-border routing results via their own GUI), the coverage of these services can be extended to the effect that transnational routing can be offered. In order to communicate with other nodes of the distributed system, every local journey planner will have to develop a web service using the common Open API interface, which will have to be able to transfer data in a translated format between local protocols and the ones used by the distributed system.

In case the local systems are overlapping, the system with extended coverage could cover the routing between the exchange points without the necessity to involve the IRS.

3.3.4 OTHER COMPONENTS

In addition to the entities mentioned above, there are other main components that need to be defined and set within the system architecture, which is the actual Open API interface, but also the exchange points and the gazetteers. These components are defined as follows within the system:

OPEN API INTERFACE

This is the key element in the present concept for transnational journey planning. The Open API interface is responsible to ensure the connection and interoperability of the local route planners (referred to as home systems in the Open API technical specification). It will be implemented according to the CEN/TC 278 technical specification for Public Transport – Open API for distributed journey planning. The protocol used for the exchange will be a simple stateless communication protocol (REST – Representational State Transfer). In order to meet the security requirements of the participating systems, encrypted and secure communication between Danube Region Journey Planner (DJPR) and Local Journey Planners (LJPs) will be applied. A Secure Sockets Layer (SSL) will be applied with two-way authentication.

EXCHANGE POINTS

Within the framework currently given in terms of European journey planners, cross-border trip planning generally includes more than one system to obtain all necessary information from. The Local Journey Planners provide routing solutions from the start to a hub or from a hub to the destination respectively. Such a hub is called an exchange point and can be considered as the point where the routing intelligence of one journey planner can end and the intelligence of another can start.

Between these exchange points, the International Routing Service (IRS) calculates the possible routes. As soon as all parts of the routing are calculated, the central node assembles the partial solutions to one routing result that can be displayed to end users.

GAZETTEER

The digital gazetteer is a structured dictionary of geographical places, such as addresses, so called “Points of Interest” (POIs) or public transport stops and stations. Each of the Local Journey Planners will have its own gazetteer from which the Danube Region Journey Planner (DRJP) can request locations. In the course of this decentralised approach, the issue of different name types from different languages needs to be tackled in the respective local gazetteers. How this will be dealt with in detail depends on the specific structure of the LJPs and has to be outlined in the development phase.

A centrally located version of the gazetteer was regarded as disadvantageous because of issues like data ownership and maintenance. However a distributed approach would bear the risk of long response times, there was confidence that this approach would be the more feasible for LinkingDanube. In order to support shorter response times, a central located cache for successful location queries will be implemented to relieve the tt from successive known location requests made in a sufficiently small time interval and to increase the efficiency of the LinkingDanube system architecture.

3.3.5 THE OVERALL SYSTEM ARCHITECTURE

The whole central-distributed system architecture for the DRJP is illustrated in FIGURE 11.

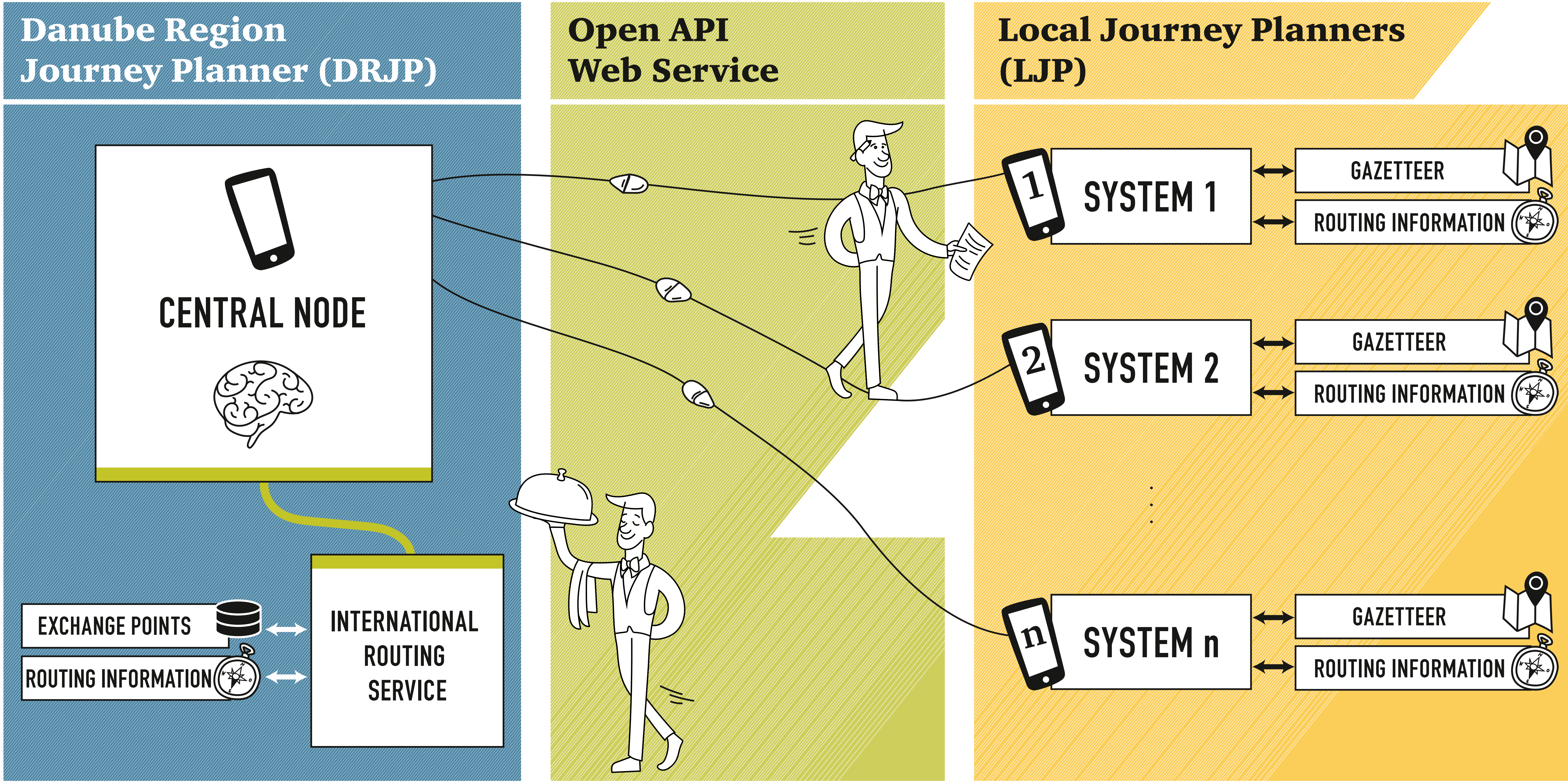


FIGURE 11: System architecture for the DRJP

4. CONCLUSIONS

A vision of a Single European Traveller Information Service was already defined by European policy with the 2011 White Paper on Transport.[18] As an integral part, the concept of linking services was first determined by the Delegated Regulation (2017/1926). By recommending the use of the Open API technical specification, this regulation has also displayed a technical and organisational possibility to realise it. Service providers are now called to set pioneering initiatives and prove the concept in the course of pilots. Projects for European cross-border cooperation such as LinkingDanube will play an important role in the piloting phase as they provide the necessary room for the proof-of-concept solutions to be elaborated. Thus they will pave the way to further development and to sustainable operation.

A major task for the near future will be to approach end users and bring to them the benefits of linking services, thus giving it more relevance and sustainability.For traveller information services to be actually accepted by the end users, they have to be centred on user needs. Great added value is seen for linking regional level services where many commuters across borders can be reached and supported. This would also follow the user-centric approach that will be necessary in order to achieve high penetration and therefore contribute to tangible improvement.

Throughout the whole variety of matters in the field of traveller information services it is no longer about technical possibilities but rather about how to use technology appropriately. Coordination must especially take place on regional level in order to achieve continuity from the end users' perspective. This means the gradual linking and improvement of services by relevant elements via channels that end users are used to. Building upon existing services will keep the barriers low from operator side while not infringing existing business models but rather enhancing them.

The recommendation must be to gather coordinated knowledge about regional mobility needs, link services on digital (i.e. traveller information and mobile ticketing) and physical level (i.e. timetable and tariff coordination) and to gradually harmonise as well as update user interfaces with cross-border traveller information and market the improvements on broad level.

18 https://ec.europa.eu/transport/sites/transport/files/themes/strategies/doc/2011_white_paper/white-paper-illustrated-brochure_en.pdf

A distributed journey planning system makes any data exchange mechanism for route calculation obsolete. Data remain at the local source systems, where they are maintained and updated much more efficiently. This means that the end user can access information in highest quality while keeping the "look-and-feel" of his or her preferred application.

The benefit for the operators of travel information service is that they keep the sovereignty over their data. They can communicate with other systems on a peer-to-peer basis. The communication between the systems allows integration of extended travel information (from other operators and countries). Hence the service can extend its area of influence and application.

Last but not least the easier access to door-to-door information through public and multimodal transport journey planning will increase both awareness and acceptance of such environmentally-friendly means of transport. This will foster a change in the mobility behaviour as people may find a reliable and more sustainable way to travel than the private car.

The integration of alternative means of transport like demand-responsive transport (DRT) and shared mobility into journey planners and travel information services is in particular important for peripheral areas and the viability of such services. Travel information systems can help to make such services more widely known and thus increase their general acceptance. The Open API for distributed journey planning offers the opportunity to integrate such modes at the same level as the other modes, like public transport and individual modes. The integration of information across the different transport schemes can on the one hand support the complementary function of DRT for the public transport services and on the other hand strengthen the environmental alliance of sustainable transport modes.