HoPE final conference: *The Next Generation of Route Planners*
Brussels, 9 May 2017

EU Project BONVOYAGE:
A distributed approach to intermodal route planning

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PROJECT OVERVIEW

The project

- BONVOYAGE: *From Bilbao to Oslo, intermodal mobility solutions, interfaces and applications for people and goods, supported by an innovative communication network*

- Call: Mobility for Growth
- Topic: MG.7.2-2014. Towards seamless mobility addressing fragmentation in ITS deployment in Europe
- Duration: May 2015 – April 2018

Partners

Consorzio Nazionale Interuniversitario per le Telecomunicazioni	Italy
ATOS Spain	Spain
Azkar-Dachser Trasportes	Spain
CEA - LETI	France
City of Bilbao	Spain
Clúster de Movilidad y Logística, MLC ITS Euskadi	Spain
Consorzio per la Ricerca nell'Automatica e nelle Telecomunicazioni	Italy
Fluidtime	Austria
Norwegian Public Roads Administration	Norway
Stiftelsen SINTEF	Norway
Trenitalia	Italy

Project goals

- Find the **best way to go from a place to another**, door to door, by using any combination of any transport means
- Design, develop and test a **federated platform, optimizing multimodal transport of passengers and goods, and fostering eco-friendly behavior**
- The platform is supported by an **innovative communication network** that collects and distributes all the data required to optimize a travel

THE BONVOYAGE APPROACH TO INTERMODAL ROUTE PLANNING

The vision is driving our approach

The vision of the BONVOYAGE project is twofold:

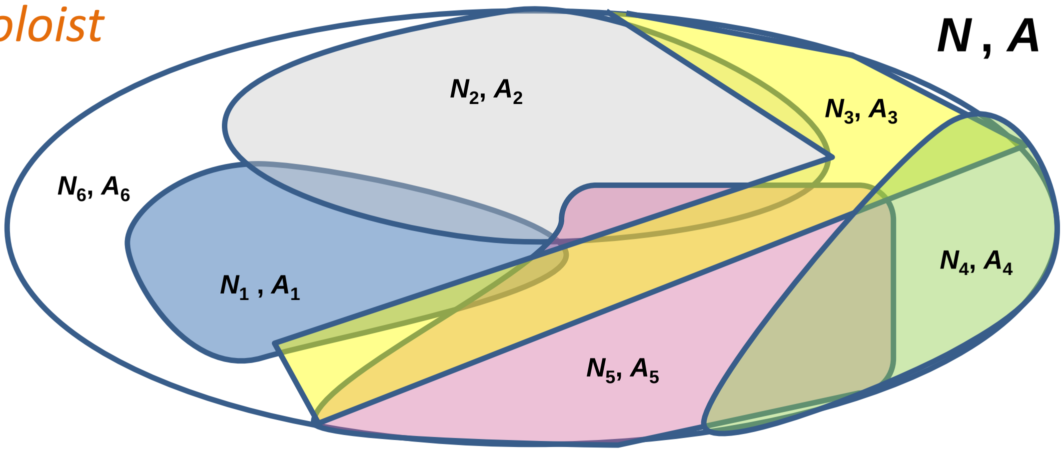
- for the end-users, to provide the best information to go from a place to another, before and during the travel, door to door, by using any combination of any transport means, both for people and goods, taking into account real-time conditions and user preferences
- for the EU and ITS community, to provide an open and federated architecture able to cluster planning services and data sources, exploiting the functionality of an innovative information-centric networking approach

Further motivation for our approach

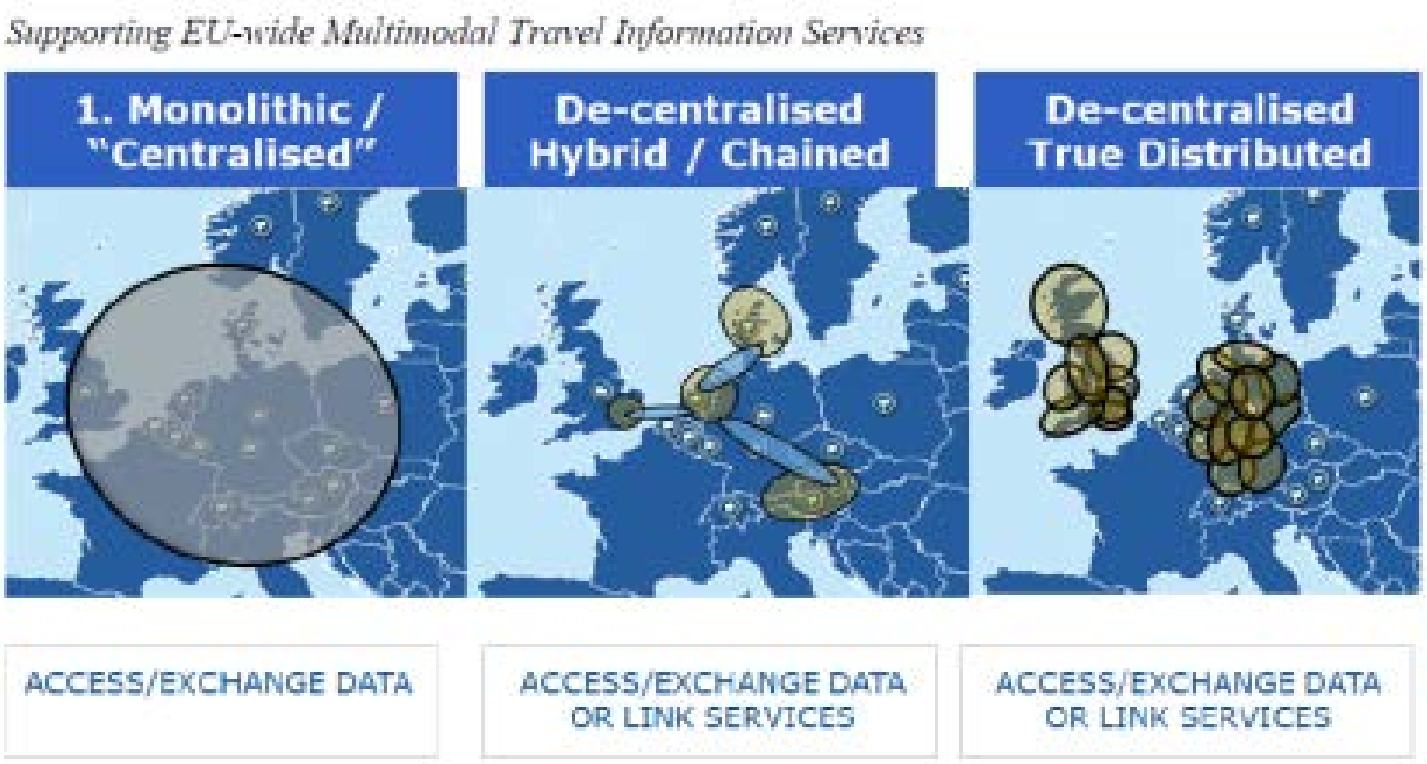
- Many of the centralized journey-planners currently available on the market have the limitation that the scope of route searches is geographically restricted to a region or a metropolitan area or specialized for one transport mode.
- Although theoretically possible, to organize and exchange raw transit and schedule data for an entire continent, such that a planner instance has access to all relevant schedule data, this is practically not feasible when:
  - real time constraints are to be taken into account;
  - personalized user profiles are involved;
  - concerns about openness of data on the part of the cautious transport operators;
  - it would be hard to convince transit businesses or authorities about their need to allocate funds to ITS applications with a worldwide scale, even though the costs of computational resources are becoming cheaper.

A distributed decomposition approach

- The *orchestrator* (*N, A*) is a decomposition algorithm *A* to compute optimal routes in a large multi-modal network *N*
- We assume that we have at hand a set of (multimodal) subnetworks N_1 , … , N_q so that $N_1 \cup N_2 \cup \cdots \cup N_q = N$.
- Also, for each subnetwork N_i we have an algorithm A_i which finds the most optimal routes
- We call the pair (N_i , A_i) a *soloist*
- Example subnetwork N_i
  - *Car*
  - *Railway*
  - *Car + pedestrian + bus*
  - *Airport terminal layout*
  - *Metro + car pooling + …*



The draft regulation for EU-wide multimodal travel information services (Action A)

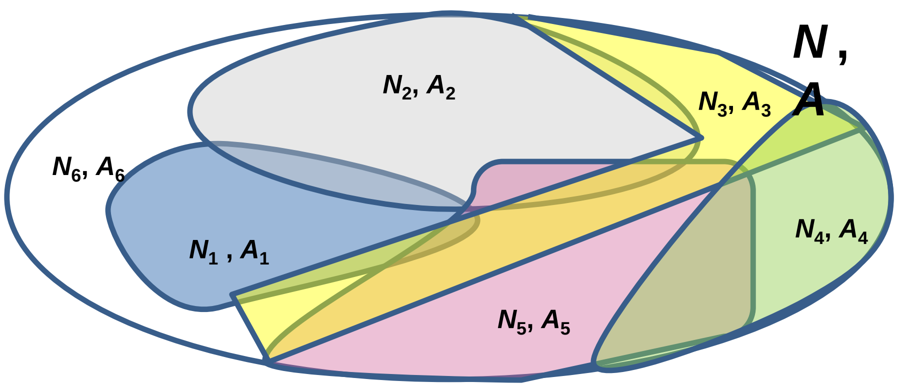


Tasks of the orchestrator

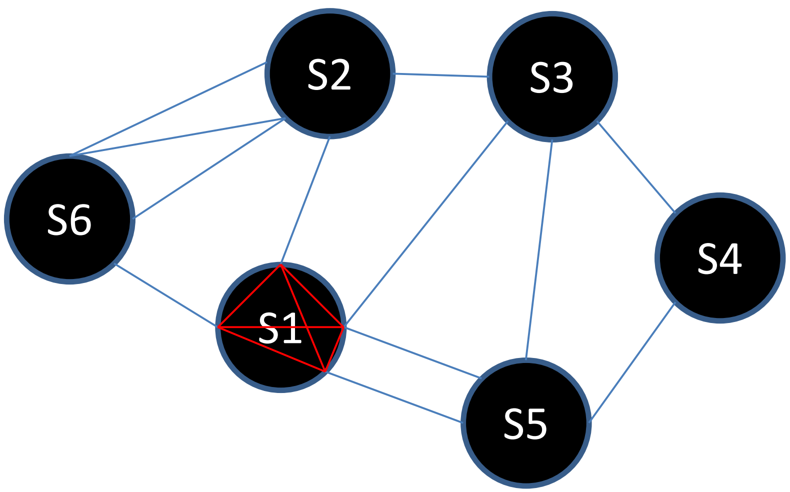
- The orchestrator maintains an overlay graph of soloists as journey planning services become available
- Once a query is submitted to the orchestrator, it will
  - Identify a suitable collection of soloists to answer the query
  - Construct the proper query for each soloist
  - Collect answers from soloists
  - Compose a complete solution (possibly several alternative routes)

The orchestrator algorithm

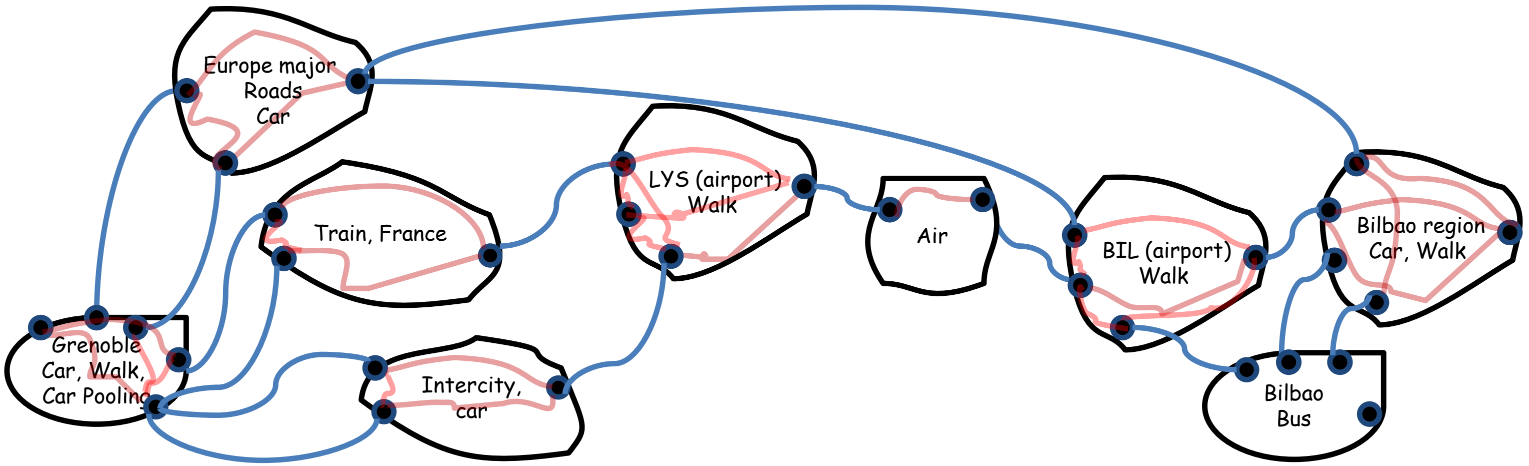
- Each soloist $S_i = (N_i\ , A_i)$ is represented in the *orchestrator graph* by a clique of *transition nodes*.
- Lower-bound values between transition nodes within the soloist S_i are pre-computed by A_i for each cost dimension (distance, duration, pollution, price, etc.)
- The orchestrator computes a set of pareto optimal paths through the orchestrator graph



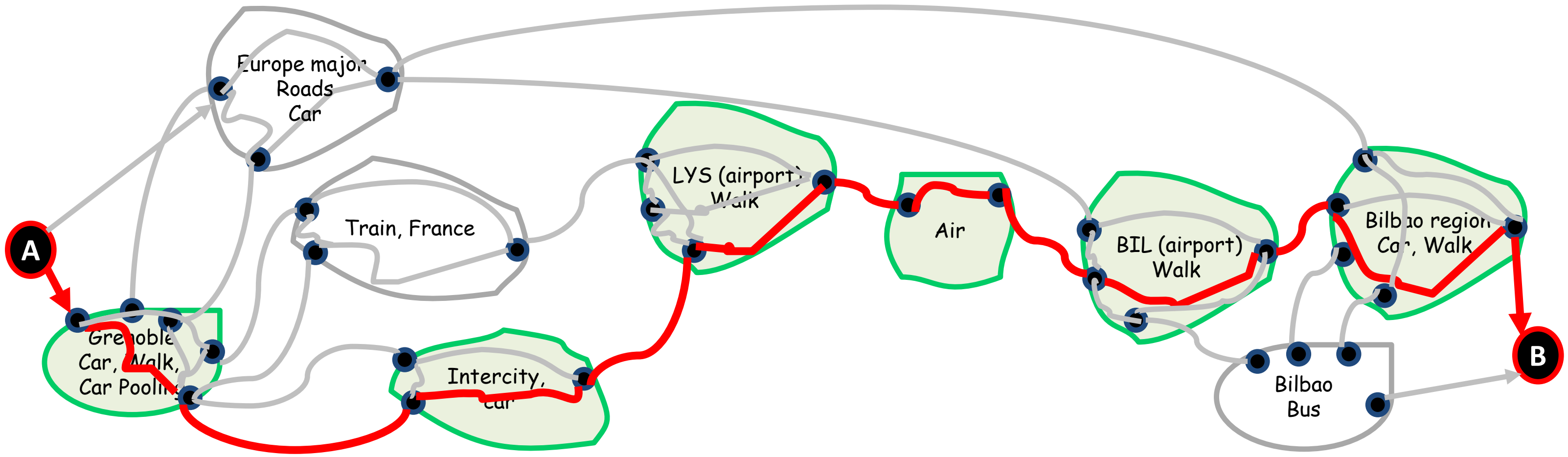
orchestrator graph

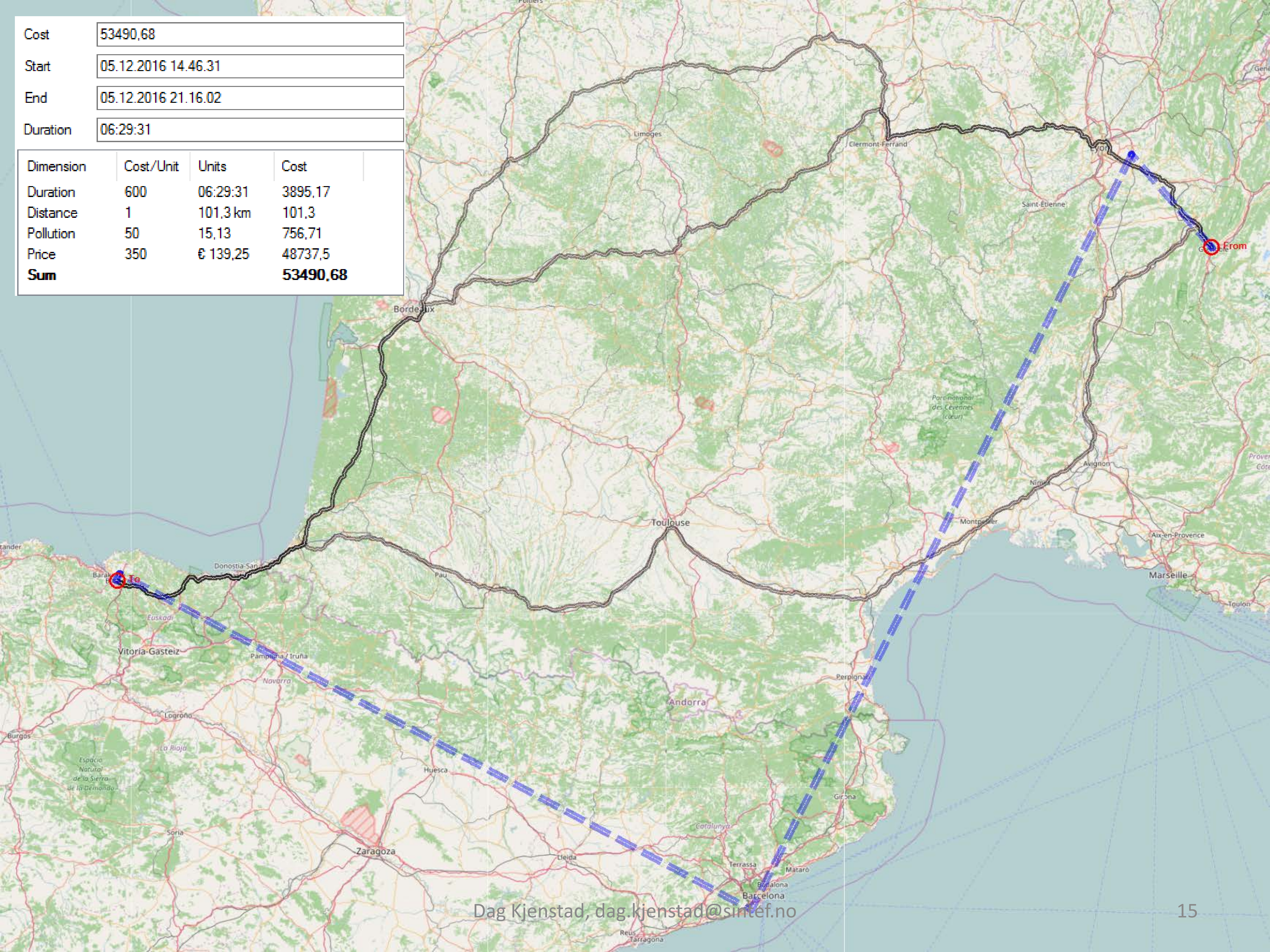


An example orchestrator overlay graph



An example orchestrator overlay graph with an optimal path for a given request





Cost 53490,68

Start 05.12.2016 14.46.31

End 05.12.2016 21.16.02

Duration 06:29:31

Dimension	Cost/Unit	Units	Cost
Duration	600	06:29:31	3895,17
Distance	1	101,3 km	101,3
Pollution	50	15,13	756,71
Price	350	€ 139,25	48737,5
Sum			**53490,68**

The features of the approach

- The decomposition allows for significant speed-ups in answering queries
- The complexity of idiosyncratic domains are handled within dedicated soloists
- The different soloists may be designed and implemented by different organizations
- The decomposition is metric-independent so it can be used in conjunction with different (e.g., personalized) objective functions. The only required property is that such functions are separable in terms which may be associated with the components of the decomposition

Pending activities

- Full integration of the framework (sensors, clients, application servers, data sources, etc.)
- Tests of scalability and solution optimality
- Tests of load stress and horizontal scalability
- Performance analysis in realistic scenarios

Summary and conclusion

- Our approach is a collaborative framework of distributed optimization services
- The collaboration is achieved by means of dedicated orchestrator services, e.g., national access points
- This approach enables the necessary scalability to handle continent-wide travel networks combined with personalized travel preferences and real-time events
- Hence, the resulting solutions are truly intermodal, handling combinations of any private and public modality in the same journey
- The concept of “orchestration of soloists” adapts to the draft regulation for EU-wide multimodal travel information services (Action A) and the need to link services via transition nodes

http://bonvoyage2020.eu/