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Smart design of tourist routes

PROGRAMA IBEROAMERICANO CYTED CIENCIA Y TECNOLOGÍA PARA EL DESARROLLO

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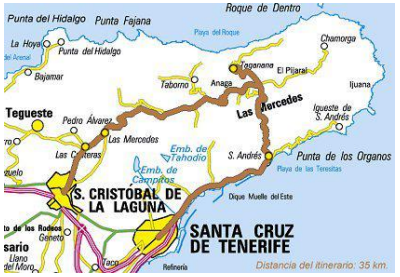
INSTITUTO UNIVERSITARIO DE DESARROLLO REGIONAL

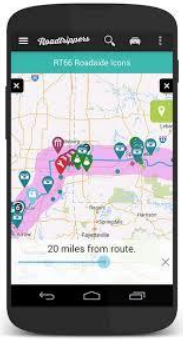
GCi Grupo de Computación Inteligente

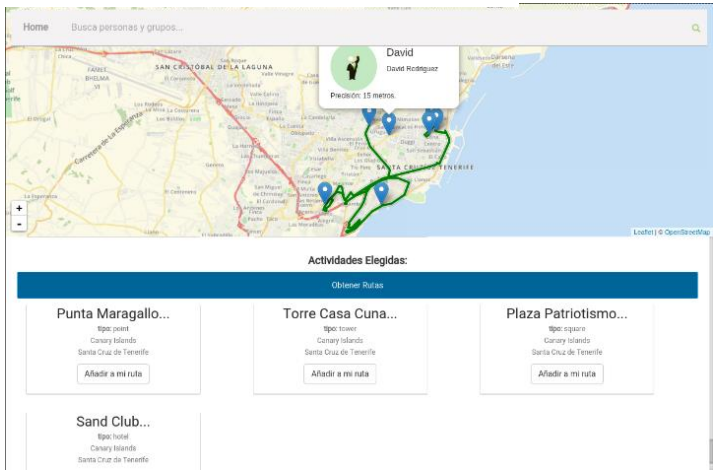
Workshop
Networks CYTED-2016 & TRA2015
smartlogistics@ib
Madrid. November 28-29. 2016

Outline

- Motivation
- Problems
- Smart tools
- Solution Approaches
- Conclusions







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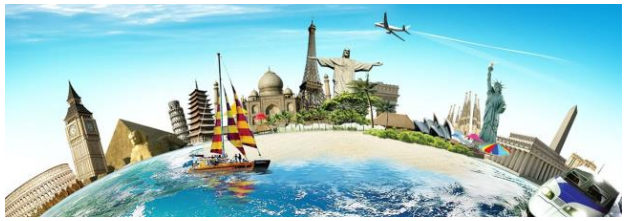


Turism

Tourism is a **world** relevant activity:

- Tourism account **10%** of the world's GDP (>**1** Billions €)
- International tourism increases yearly about **5%**.
- Represents **7%** of the world's exports; **30%** in service
- Tourism supports about **1/11** jobs around the globe.
- > **1.186** millions international tourists (**1.800** for 2030)
- **6.000** millions domestic tourist

[***UNWTO Tourism Highlights***, 2016]

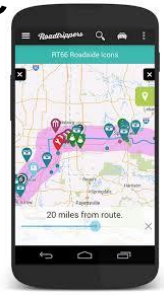
Spain

- > **70** millions visitors (**12** millions in ***Canaries***)
- > **60.000** millions € (**70%** GDP in ***Canaries***)

Islas Canarias

Smart turism

- Tourism includes the **movement** of people
- People are fully ***connected***
- Facilities are ***connected***
- Technical and research challenges:
  - **Web applications for tourists** (at origin)
  - **Mobile apps for tourists** (at destination)
  - **Smart tourism** (business, users, …)
  - **Personalized Electronic Tourist** (PETs) guides
  - **e-tourism**
  - **Recommender Systems**
  - **Trip Recommenders**
  - **Location-based recommenders**
- **Smart Tourist Route Design**



tripadvisor®

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eCOMPASS:
e**CO**-friendly urban
Multi-modal route
PlAnning **S**ervices
for mobile u**S**ers

From **Gavalas *et al*. (2014) *JoH*** 20(3)

Real-time multimodal public transportation data

Context sensor data (e.g. weather, traffic conditions)

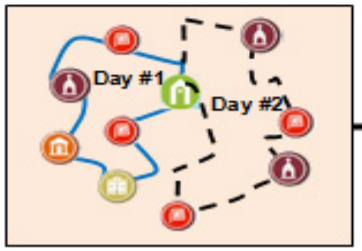
User preferences/ constraints and mobile user context

POIs data

Web user

Tourist itineraries optimization logic

Mobile user



Daily personalized tourist itineraries

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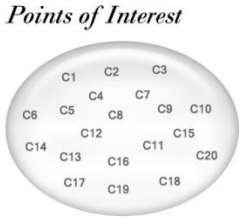
Tourist Trip Design

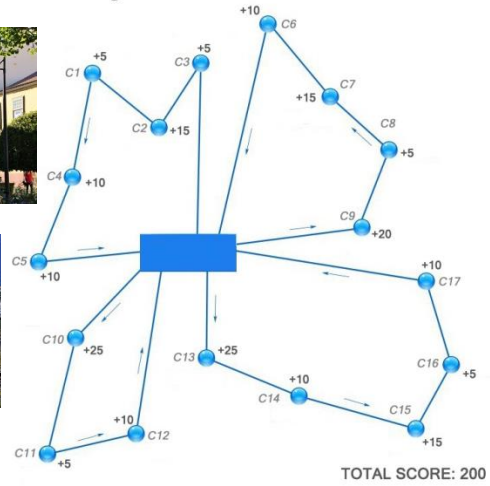
The **Tourist Trip Design Problems** (**TTDP**) refer to planning routes for tourists interested in visiting multiple **Points of Interest** (**POIs**).

- Tourist destinations has multiple POIs; tourist attractions.
- POIs: the main reason why tourists visit the destination.
- The tourist has a limited time and budget to visit POIs.
- Tourists plan trips based on:
  - Personal **preferences**
  - POIs **features**
  - **Distance/Time**



Objectives vs. constraints: profit, cost, time

- **Single routing**: TSP with profit (TSPP);
- **Multiple routing**: VRP with profit (VRPP)



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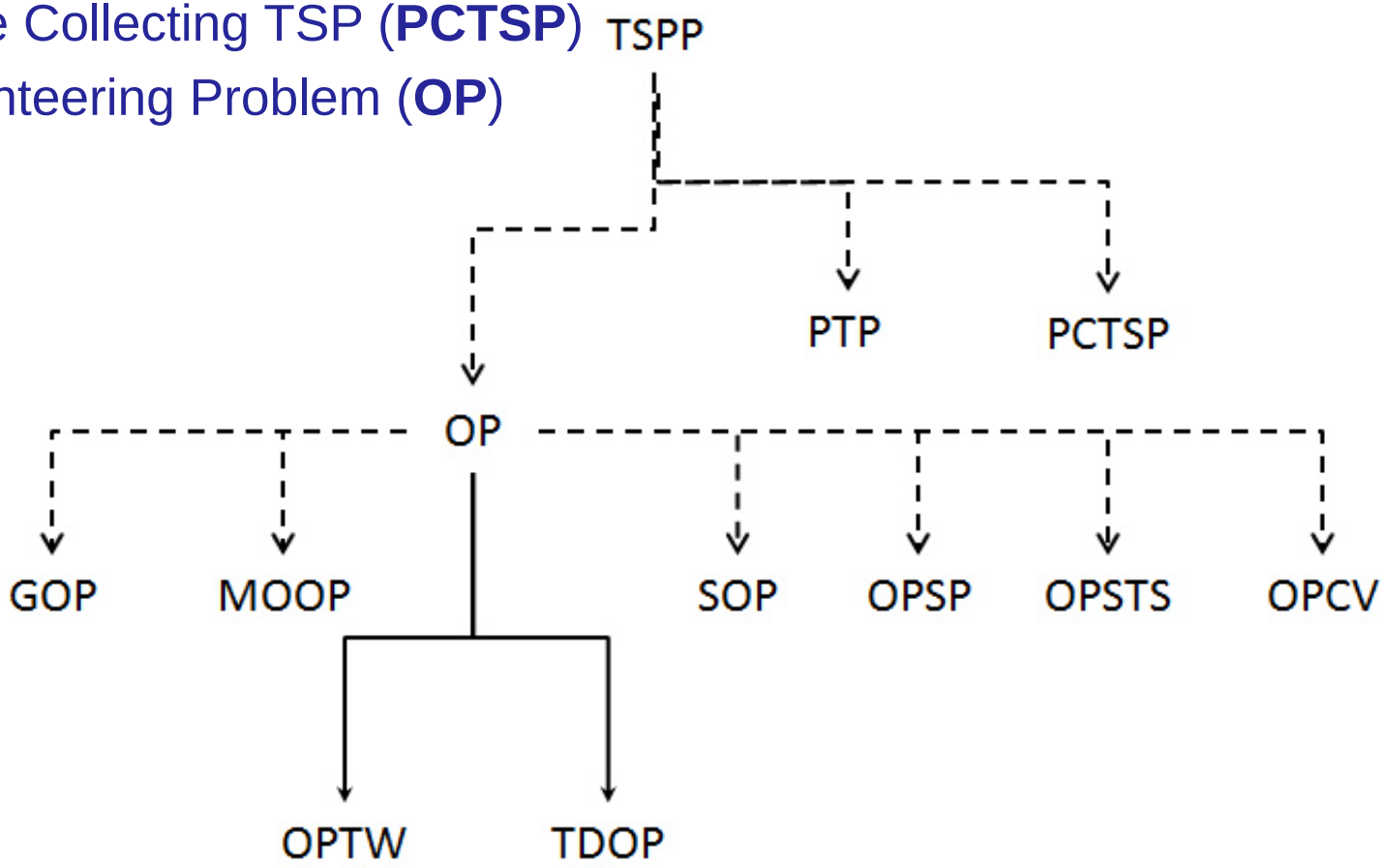
Single Routing TTDP

Single routing: TSP with **profit** (TSPP); a score at each POI

- The Profitable Tour Problem (**PTP**)
- The Prize Collecting TSP (**PCTSP**)
- The Orienteering Problem (**OP**)



Single Routing TTDP

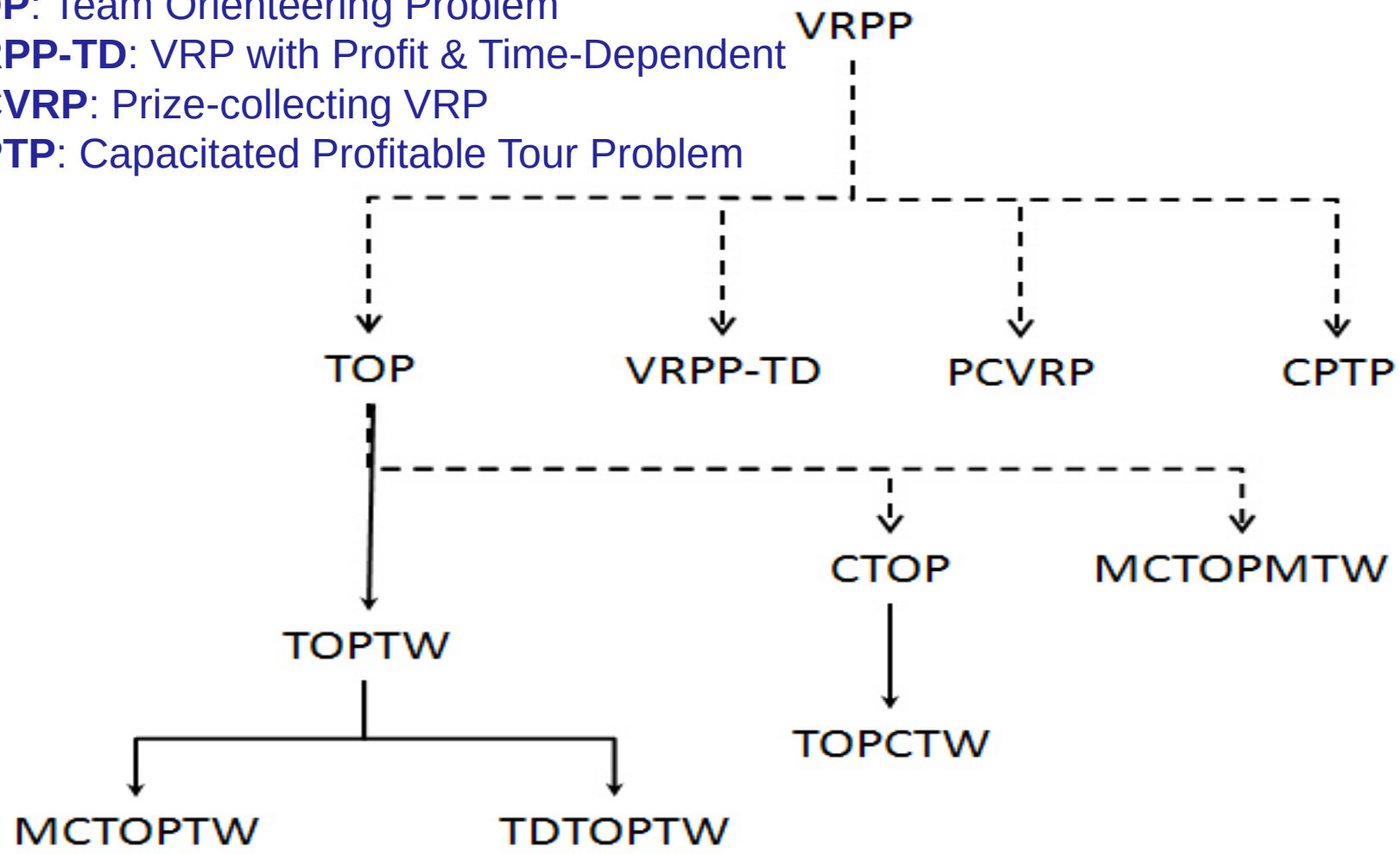
Single routing: TSP with profit (TSPP)

- The **Profitable Tour Problem** (PTP): maximizing profit – cost
- The **Prize Collecting TSP** (PCTSP): minimizing cost s.t. profit
- The **Orienteering Problem** (OP): maximizing profit s.t. cost/time
    - **GOP**: Generalized OP (several features of POIs)
    - **MOOP**: Multi-objective OP
    - **OPTW**: OP with Time Windows
    - **TDOP**: Time-Dependent OP
    - **SOP**: Stochastic OP (stochastic service time)
    - **OPSP**: OP with Stochastic Profits
    - **OPSTS**: OP with Stochastic Times and Service times
    - **OPCV**. OP with Compulsory Visits
    - **OPVP**: OP with Variable Profits
    - **OPHS**: OP with Hotel Selection

Multiple Routing TTDP

Multiple routing TTDP: VRP with profit (VRPP)

- **TOP**: Team Orienteering Problem
- **VRPP-TD**: VRP with Profit & Time-Dependent
- **PCVRP**: Prize-collecting VRP
- **CPTP**: Capacitated Profitable Tour Problem



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Multiple Routing TTDP

Multiple routing TTDP: VRP with profit (VRPP)

- **TOP**: Team Orienteering Problem:
  - **TOPTW**: TOP with TW
    - **MCTOPTW**: Multiple-Constrained TOP with TW
    - **TDTOPTW**: Time-Dependent TOP with TW
  - **CTOP**: Capacitated TOP
    - **CTOPTW**: Capacitated TOP with TW
  - **MCTOPMTW**: Multiple-Constrained TOP Multiple-TW
- **VRPP-TD**: VRP with Profit & Time-Dependent
- **PCVRP**: Prize-collecting VRP
- **CPTP**: Capacitated Profitable Tour Problem

Arc Routing TTDP

Traversing **arcs** with the POIs

- City streets with monuments or interesting building
- Rural roads with viewpoints or interesting villages

Arc Routing Problems (ARP): Corberán & Laporte (2014)

- Prize-collecting Rural Postman Problem (**PRPP**),
- Arc Orienteering Problem (**AOP**),
- Team Orienteering Arc Routing Problem (**TOARP**),
- Undirected Capacitated ARP with Profits (**UCARPP**).

- **Mixed problems**: visiting nodes and arcs

MIP formulation

- Derived from standard VRP formulation:
  - Decision variables: **visiting POIs**: y_{ik} (visit POI i at day k)

minimize $\sum_{(i,j)\in A}\sum_{k\in V} c_{ij}z_{ijk}$ **maximize** $\sum_{i\in N}\sum_{k\in V} s_i y_{ik}$

subject to:

$$\sum_{k\in V} y_{ik} \geq 1 \qquad i \in C \qquad \text{(Assignment)}$$

$$\sum_{(i,j)\in A} z_{ijk} = y_{ik} \qquad i \in N,\ k \in V \qquad \text{(LeaveNode)}$$

$$\sum_{(j,i)\in A} z_{jik} = y_{ik} \qquad i \in N,\ k \in V \qquad \text{(EnterNode)}$$

$$\sum_{(j,i)\in A} x_{jik} - \sum_{(i,j)\in A} x_{ijk} = d_i y_{ik} \qquad i \in C,\ k \in V \qquad \text{(FlowBalance)}$$

$$x_{ijk} \leq L z_{ijk} \qquad (i,j) \in A,\ k \in V \qquad \text{(VehicleCapacity)}$$

$$y_{1k} = 1 \qquad k \in V \qquad \text{(Depot)}$$

$$x_{ijk} \geq 0 \qquad (i,j) \in A,\ k \in V$$

$$y_{ik} \in \{0,1\} \qquad i \in N,\ k \in V$$

$$z_{ijk} \in \{0,1\} \qquad (i,j) \in A,\ k \in V$$

Early studies

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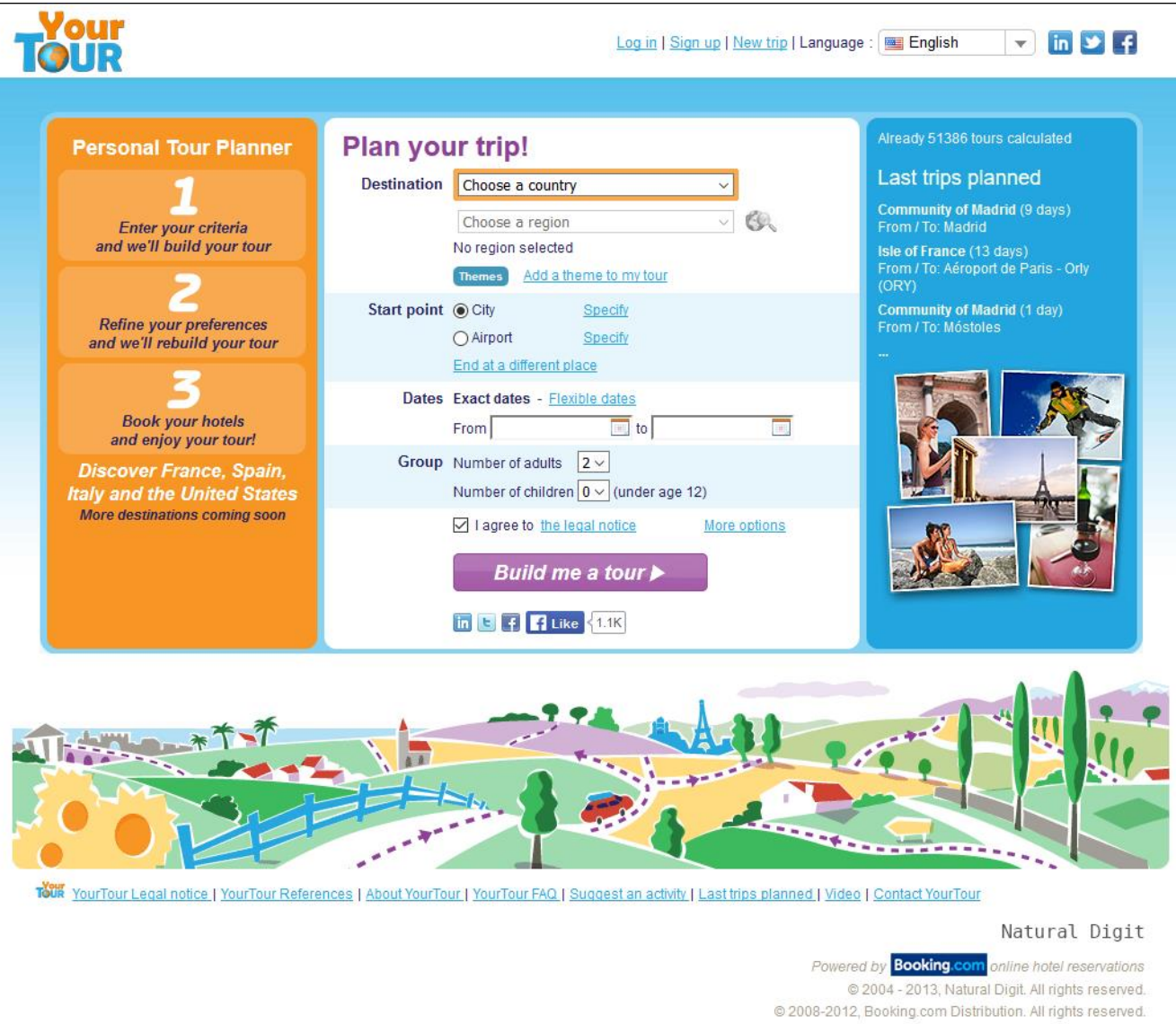
- J.M. **Godart** (2005). Challenges in real world sightseeing tour optimization using meta-heuristics. EC'05 Proceedings of the 6th WSEAS international conference on Evolutionary computing. (pp. 233-238).

http://www.yourtour.com/

YourTour


Your TOUR
Log in | Sign up | New trip | Language : English
Personal Tour Planner
1
Enter your criteria and we'll build your tour
2
Refine your preferences and we'll rebuild your tour
3
Book your hotels and enjoy your tour!
Discover France, Spain, Italy and the United States
More destinations coming soon
Plan your trip!
Destination
Choose a country
Choose a region
No region selected
Themes
Add a theme to my tour
Start point
City
Specify
Airport
Specify
End at a different place
Dates
Exact dates - Flexible dates
From
to
Group
Number of adults 2
Number of children 0 (under age 12)
I agree to the legal notice
More options
Build me a tour
Like 1.1K
Already 51386 tours calculated
Last trips planned
Community of Madrid (9 days)
From / To: Madrid
Isle of France (13 days)
From / To: Aéroport de Paris - Orly (ORY)
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Vansteenwegen's contributions

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http:// www.citytripplanner.com

eCOMPASS

eCOMPASS: FP7-ITC (2011-2014), Smart Cities & Sustainability
eCO-friendly urban Multi-modal route PlAnning Services for mobile uSers

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- **DAILYtrip** web/mobile app.

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THINGS TO DO | ATTRACTIONS | IN 1 TO 4 DAYS | TRAVEL TIPS | TOURIST MAP

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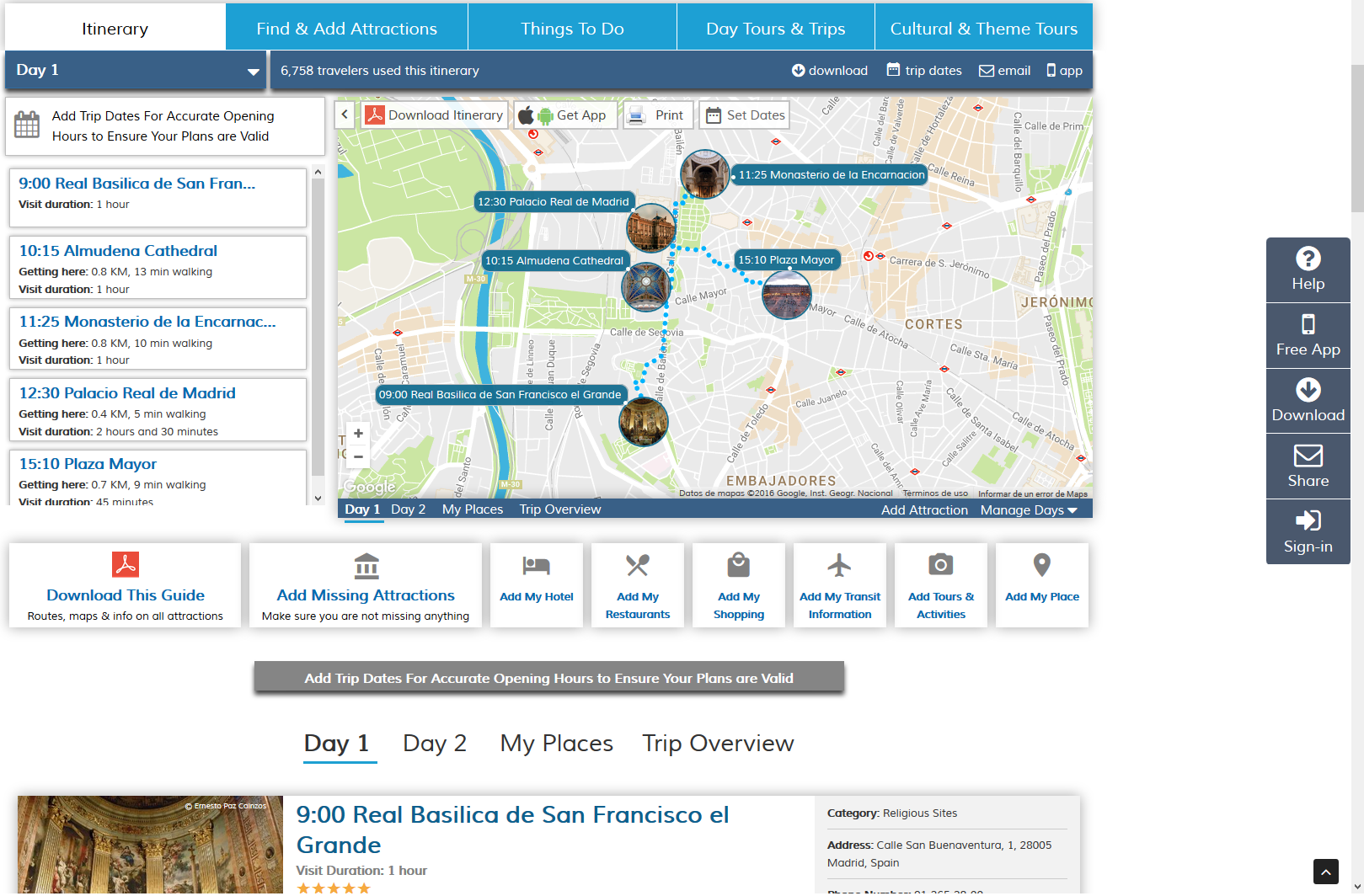

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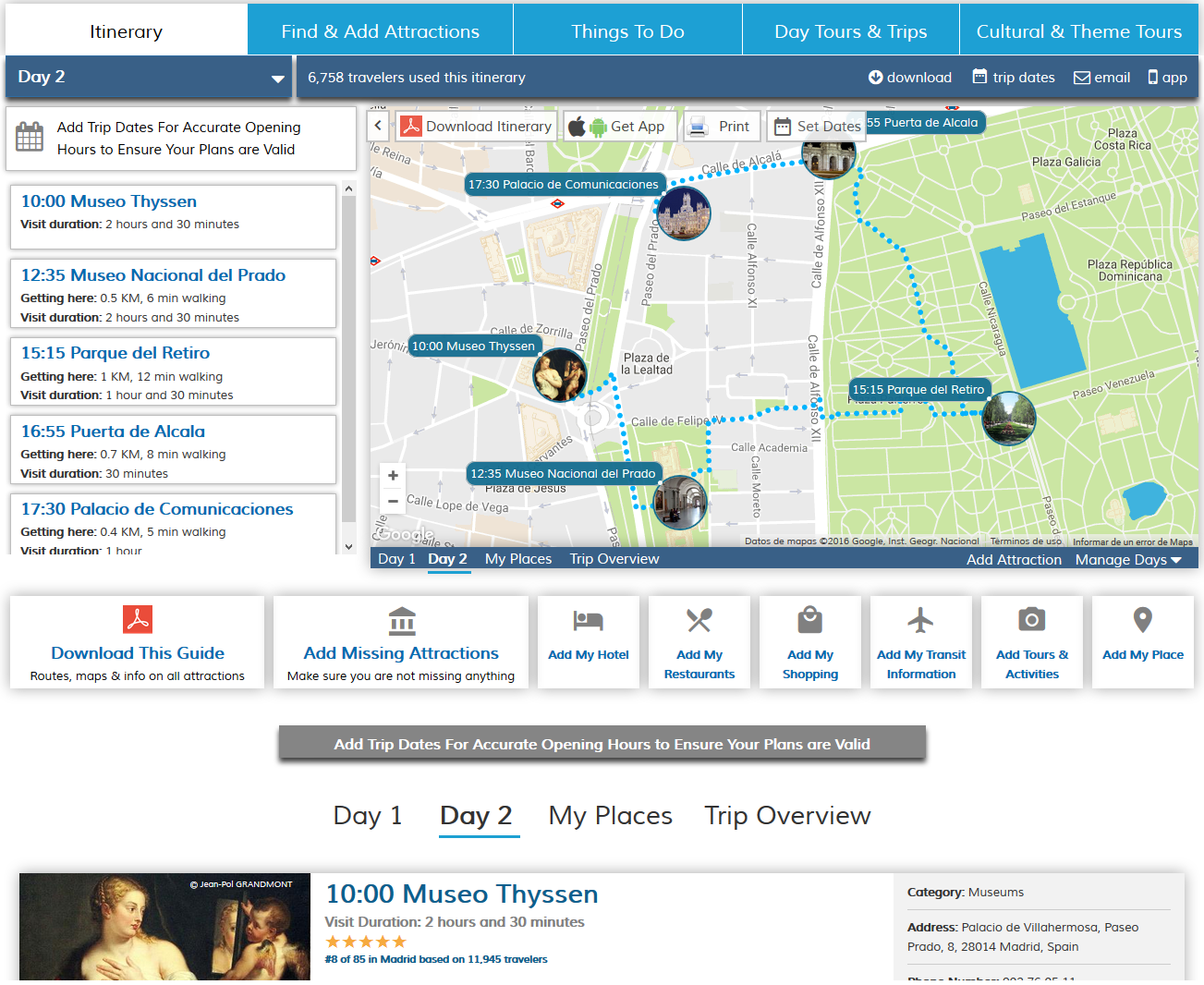
Day 2



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Recent References

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- **e-Review of Tourism Research** (**eRTR**); a web-based, bimonthly international research network for tourism professionals.

- **S. Ribeiro** (2016). Design and Evaluation of a Heuristic Algorithm for Recommending Travel Regions. **Master's Thesis**, Department of Computer Science, Technical University of Munich, Germany.
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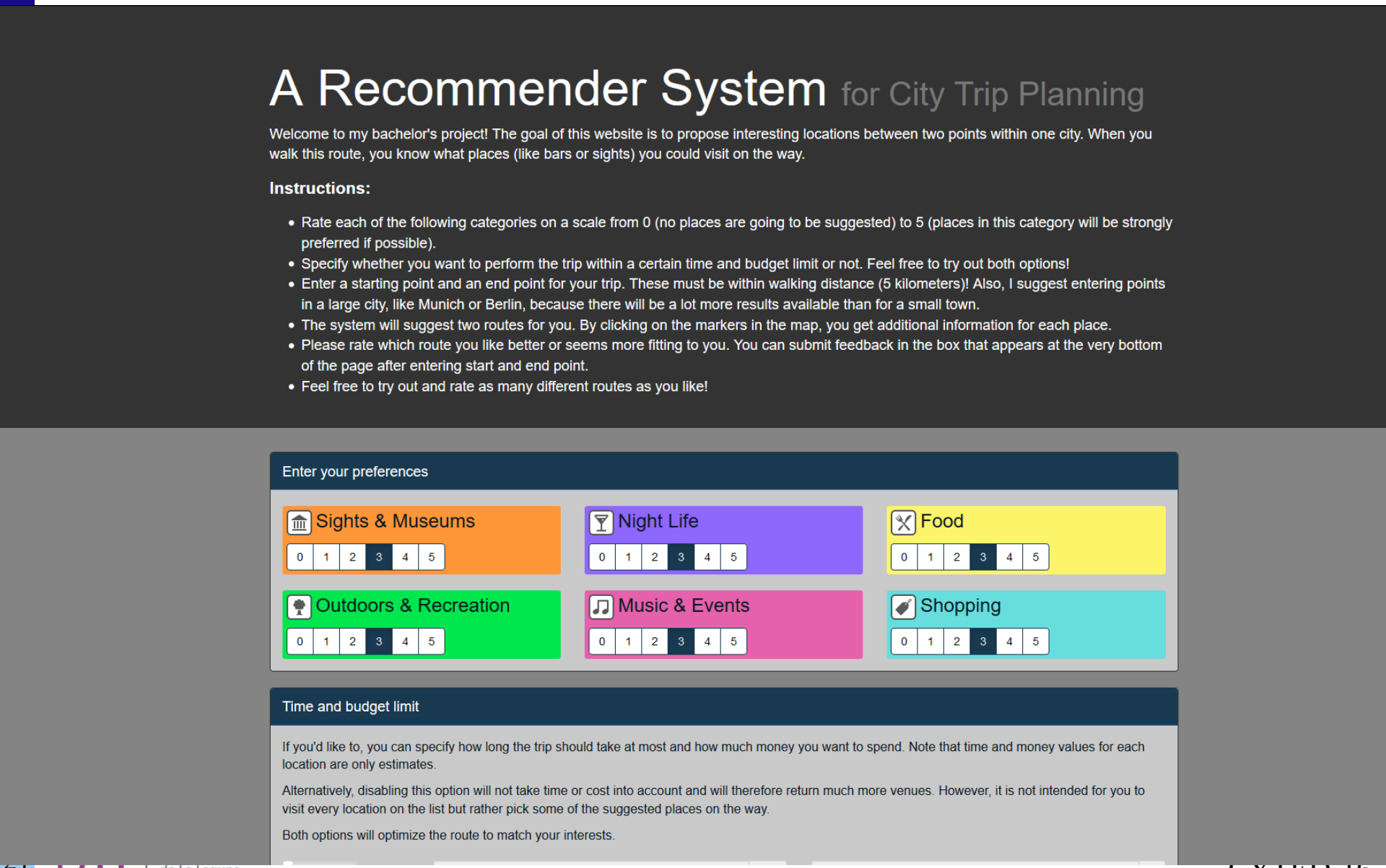
  Solving Tourist Trip Design Problems from a User's Perspective
  http://citytrip.traveller-world.com (**27.06.2016**)

http://citytrip.traveller-world.com

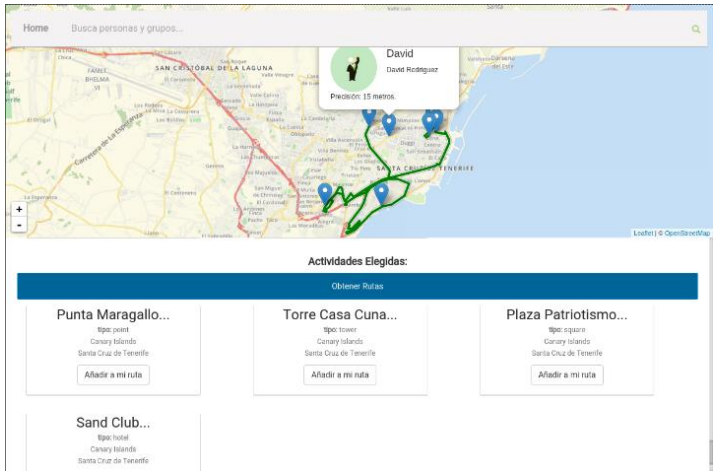


Our propossals

- **Metaheuristic approach: GRASP-VNS hybrid**
  - GRASP (Greedy Randomized Adaptive Search Procedure)
    Iterative greedy/randomized construction steps.
  - VNS (Variable Neighbourhood Search)
    Systematic change in the improving movements.
- **Fuzzy approach: Fuzzy objectives and/or constraints**
  - Fuzzy travel times are fuzzy.
  - Fuzzy scores at POIs.
  - Fuzzy values are Triangular Fuzzy numbers.

[Classical T. Tsiligirides (1996) TOP ***instances***]

- **Smart tourist routes planning by geo-social recommendation**
  - Based on ***Vidali***; a geo-referenced location based social network
    - Social network that includes geo-referenced information



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Our contributions

- ***Tourist Trip Planning with Fuzzy Preferences and Constraints***
  International Conf. of O.R., La Habana, March 2016
- ***Solving the Team Orienteering Problem with Fuzzy Scores and Constraints***
  IEEE Intern. Conf. on Fuzzy Systems, Vancouver, July 2016
- ***A Heuristic-Biased GRASP for the Team Orienteering Problem***
  MAEB 2016, Salamanca, September 2016.
- ***Service of intelligent planning of tourist routes based on the geo-social recommendation***
  Master's Thesis. Department of Computing Engineering, ULL
  Student: Christopher David Caamana Gómez, July 2016

Metaheuristic Approach

GRASP-VNS hybrid approach:

- **GRASP**: (Greedy Randomized Adaptive Search Procedure)
  Mechanism that builds a solution step-by-step by adding a new element from a restricted candidate list (RCL) to the current partial solution.
  - **RCL**: POIs to be added to the partial set of routes
    - RCL sorted by score.
    - RCL sorted by travel time.
  - **Selection**: (biased) random with different probability distribution
- **VNS**: VND (Variable Neighbourhood Descent)
  Mechanism that improves the solution changing the neighbourhood
  - **Moves** associated to each neighbourhood:
    - Insert a new POI
    - Relocate POIs
    - Exchange POIs
- **Instances**:
  - Adaptation of **T. Tsiligirides** (1996) classical instances for TOP.

Fuzzy Approach

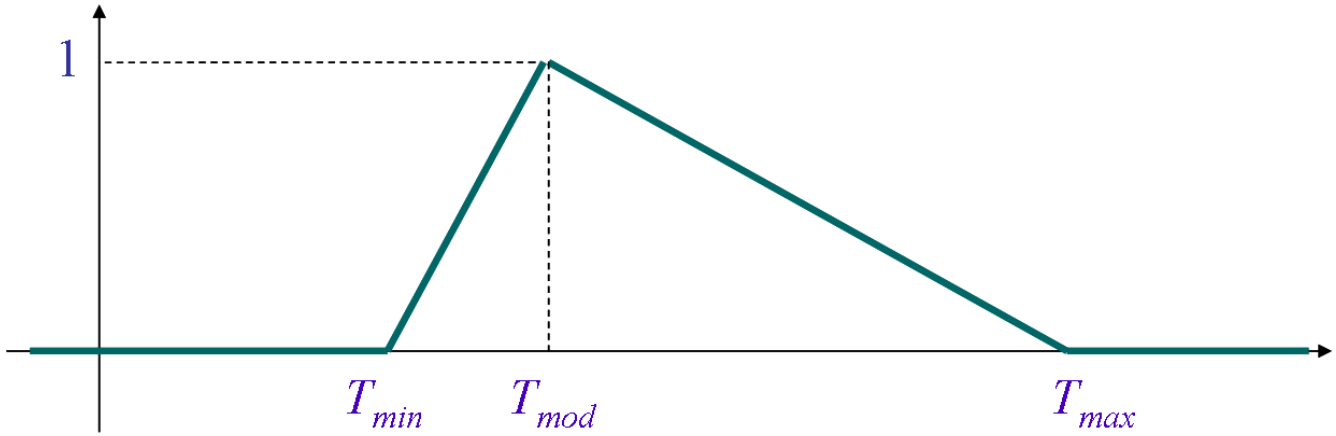
Uncertainty: fuzzy features of the problem

Fuzzy optimization problem:

Fuzzy scores: fuzzy objectives

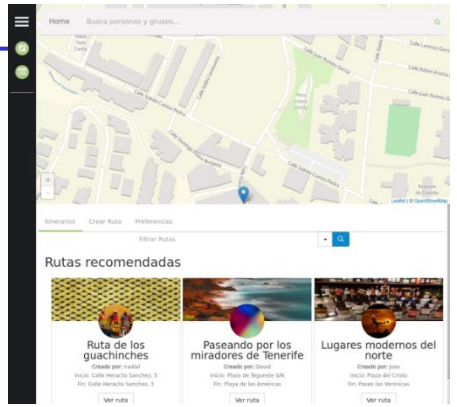
Fuzzy travel time: fuzzy constraints

- **Fuzzy Triangular Numbers**



- Using **α-cuts** and **tolerance** levels for constraints.
- Ranking fuzzy values by the **Yager's third index**

Main challenges



- **Adaptability**:
  - Dynamism (robustness)
  - User adaptation

- The role of **Social Networks**:

- **Evaluation**: the order is important; clustered; POIs features
- **Serendipity**: discovering a new interest that the user had no idea about
- **Group** Recommendation:
- **Privacy**:
- **Mobile apps**:
- **Integration** with other tools:

STRInG
Smart Tourist Routes for Inclusive Groups

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Thanks

José A. Moreno Pérez , Airám Expósito Márquez,
Julio Brito Santana, Dagoberto Castellano Nieves.

Workshop
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