

# Enhancing explanations in recommender systems with knowledge graphs

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# 1-sentence summary

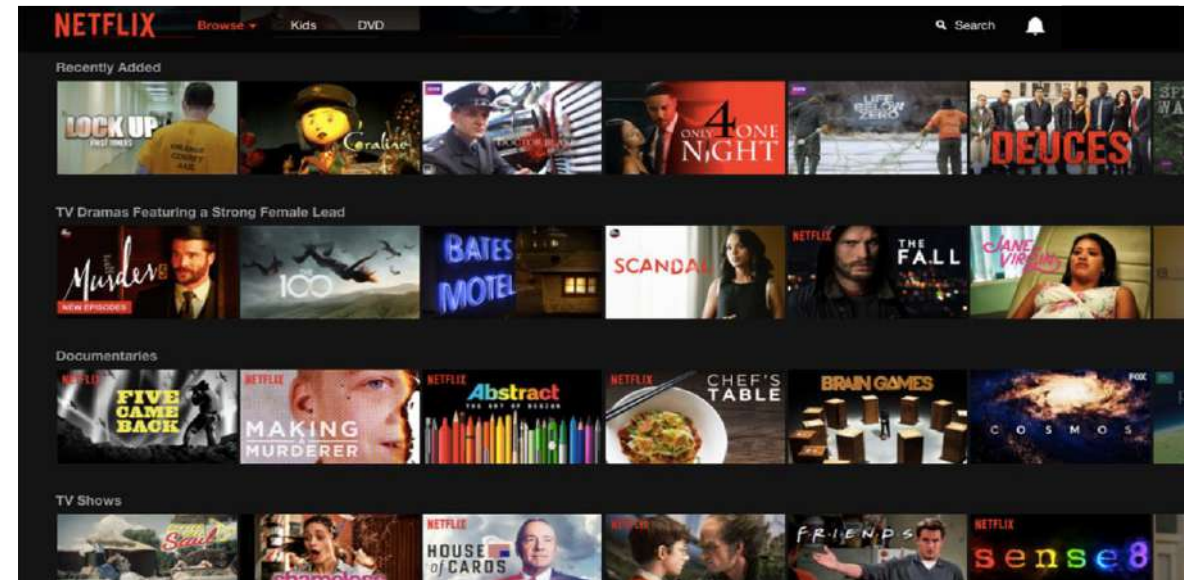
The paper proposes 3 approaches using knowledge graph technologies to remedy 3 shortcomings of existing semantic recommendation explanation approaches : (1) absence of entity filtering, (2) lack of intelligibility, and (3) poor user-friendliness.

# Background

- Recommender systems are becoming must-have facilities on e-commerce websites to alleviate information overload and to improve user experience.
- Apart from the traditional top-N item recommendation functionality, another important functionality of such systems is the explanations of the recommendations.
- An explanation is sometimes a justification of why items have been recommended, while sometimes an item description which helps users to understand the qualities of the item well enough to decide whether it is relevant for them or not.

# Background

- Technical approaches :
  - Collaborative-based (e.g. People who purchased this product also purchased...)
  - Content-based (e.g. TV Dramas Featuring a Strong Female Lead)



## Les clients qui ont acheté cet article ont également acheté

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Page 1 sur 2

A carousel of product recommendations for KitchenAid mixers and accessories. The items are displayed in a row with navigation arrows on the left and right. Each item includes an image, the product name, a star rating, and the price with a Prime logo.

5 stars	4.5 stars	3.5 stars	5 stars	4.5 stars	4.5 stars	4.5 stars	3 stars
EUR 388,00 ✓prime	EUR 142,00 ✓prime	EUR 396,00 ✓prime	EUR 138,67 ✓prime	EUR 69,00 ✓prime	EUR 55,81 ✓prime	EUR 39,90 ✓prime	

# Background

- State of the art on content-based or semantic-based recommendation explanations:
  - Approaches using structured data (knowledge graphs) and semi-structured data (processed folksonomy)
  - Approaches using unstructured data (textual description data)
- In a nutshell, the state-of-the-art approach consists of explaining with the keywords or the semantic entities extracted from the recommended item and ranked according to certain criteria.
- We choose the travel domain as a running example.

Bien-être | Randonnée / trek

à partir de 16 ans

Tranquille 

NATURE ●●●●○ CULTURE ●●●●○ RENCONTRE ●●●●○

réserver

Featured on

Coach/Bus

Cultural

Western Europe

Europe

We recommend this trip for:



Wildlife and this trip for:



### Mediterraneo Occidentale

Italia, Francia, Spagna, Isole Baleari



Prezzo a partire da  
€ 899 /pers

Adatto per...

SPIAGGE MUSEI CIBO  
CULTURA CENTRI STORICI

SCOPRI DI PIÙ

Tasse portuali e quote d'iscrizione incluse. Esclusa quota di servizio ed eventuali altri servizi facoltativi.



TRAVEL GUIDE

**Vienna**

Museums · Architecture · Culture

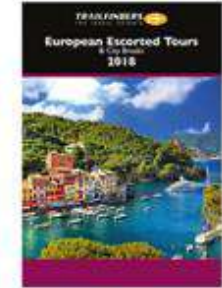


# Country Roads of Bavaria, Switzerland & Austria

## Highlights

- Munich
- Salzburg
- Vienna
- Innsbruck
- St Moritz
- Lucerne

## Brochure



[Order »](#)

**Coach (Luxury) | 12 days/11 nights**

**Guide Price £2895**

Based on 2 adults sharing a room in low season including applicable offers.

[Call for latest price and offers.](#)

[View Map](#) [Image Gallery](#)

[Book this tour »](#)



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### Day 1 Munich, Germany

Fly to Munich and transfer to your hotel before joining your Tour Director for an orientation tour of the city, seeing the Palace of the Dukes of Wittelsbach, the English Garden and the famous Marienplatz. In the evening, join your fellow travellers for a welcome reception.

### Day 2 Munich

Visit the Neuschwanstein Castle, built as a retreat for the eccentric King Ludwig II, and see the lavishly decorated apartments including the Throne Room and Lohengrin Grotto. The remainder of the day is at leisure to explore Bavaria's capital city – perhaps visit one of its many art galleries and museums, or relax and enjoy a coffee in the delightful Marienplatz.

### Day 3 Munich to Oberammergau

Head to Oberammergau, home to the famous Passion Play dating back to 1634AD performed by the inhabitants of the town once each decade. See the theatre where it is performed and the town's colourful chalets.

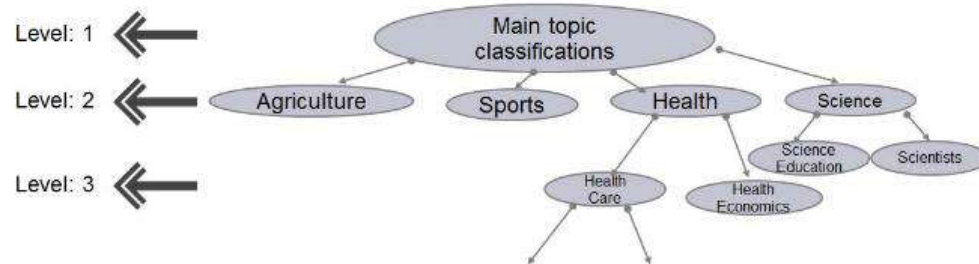
# 3 problems of the state-of-the-art approach

- Listing entities: “dbr:Marienplatz”, “dbr:Neuschwanstein\_Castle”, “dbr:Passion\_Play”.
- Problems
  - Absence of entity filtering
  - Lack of intelligibility
  - Poor user-friendliness

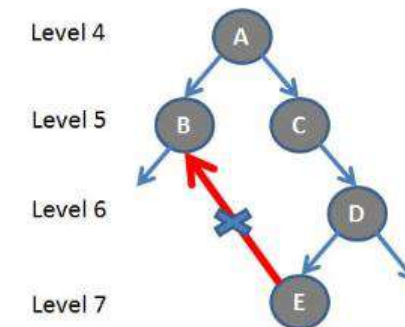


# Entity filtering with a DBpedia category tree

- In DBpedia, entities are linked to categories with “dct:subject” which reflect the subjects of the entities.
- The idea is to retain entities whose subjects are relevant for the recommendation domain, e.g “dbr:Musée\_d'Orsay” “dbc:Art\_museums\_and\_galleries\_in\_Paris”.
- The categories are hierarchically linked by “skos:broader” and cycles are present.



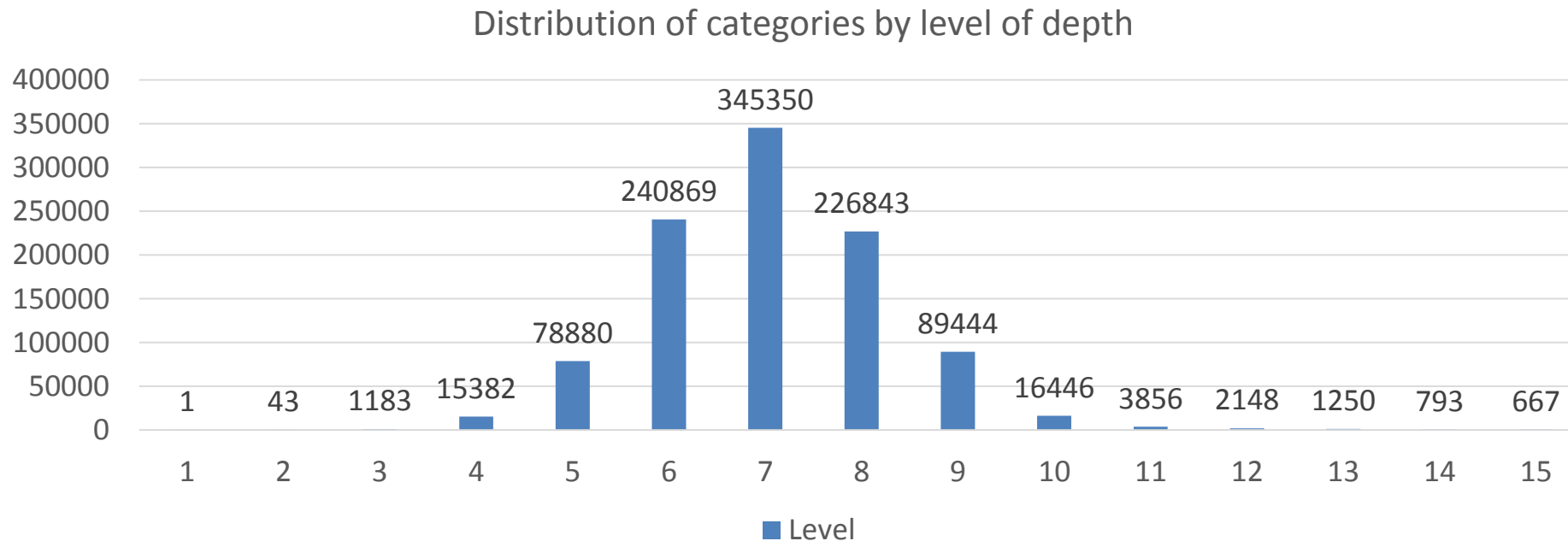
(a) Hierarchy Level Assignments



(b) Non Hierarchical Links

# Entity filtering with a DBpedia category tree

- A DBpedia category tree containing 1,023,155 categories spread over 15 levels and having as root category “dbc:Main\_topic\_classifications”



# Entity filtering with a DBpedia category tree

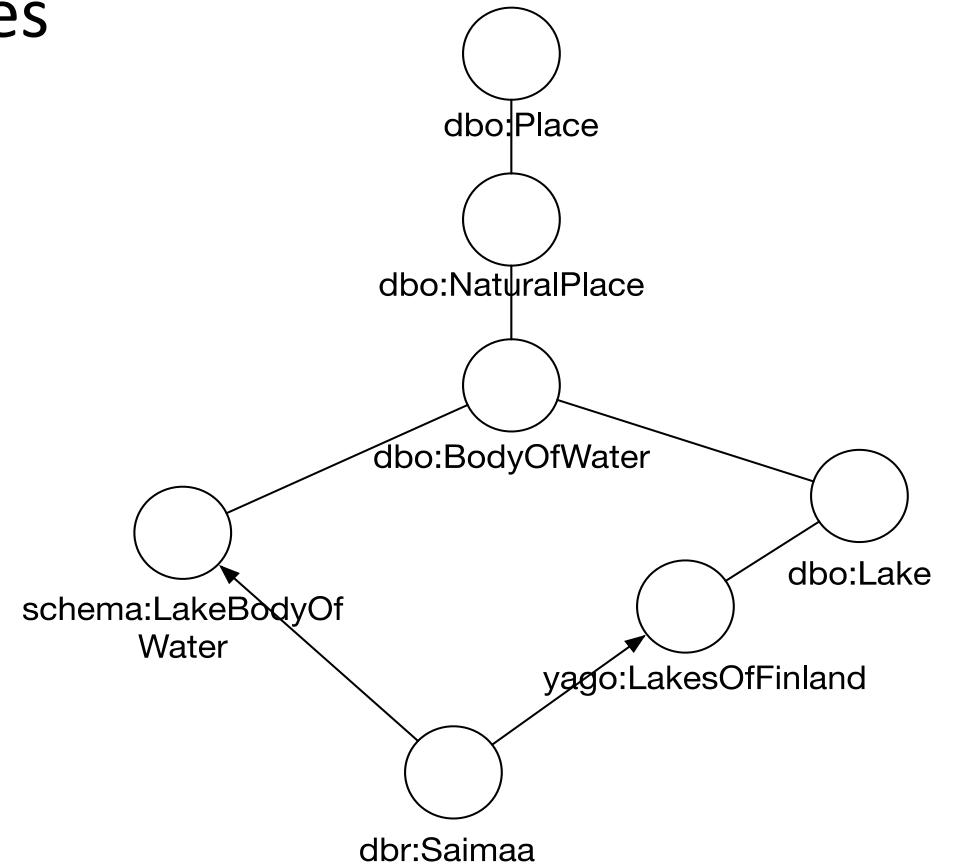
- Manual annotation of the 43 categories at level 2
- 12 annotated as relevant to the travel domain, e.g. “dbc:Arts”, “dbc:Culture” and “dbc:Nature”.
- Possible to make more fine-grained annotation by annotating categories of level 3, e.g. among the 21 sub-categories of “dbc:Culture” at level 3, we may annotate “dbc:Natural\_monuments” as relevant and “dbc:Nature\_writers” as irrelevant.
- Filtering
  - Given an entity, retrieve all linked categories
  - Relevant if at least one relevant category

# Increasing the intelligibility with ontology class

- The idea is to provide a hint to help users better understand what an entity is about.
- An integrated ontology containing 447,250 classes from DBpedia, YAGO, and schema.org, rooted on *owl:Thing* and with a depth of 19.

# Increasing the intelligibility with ontology class

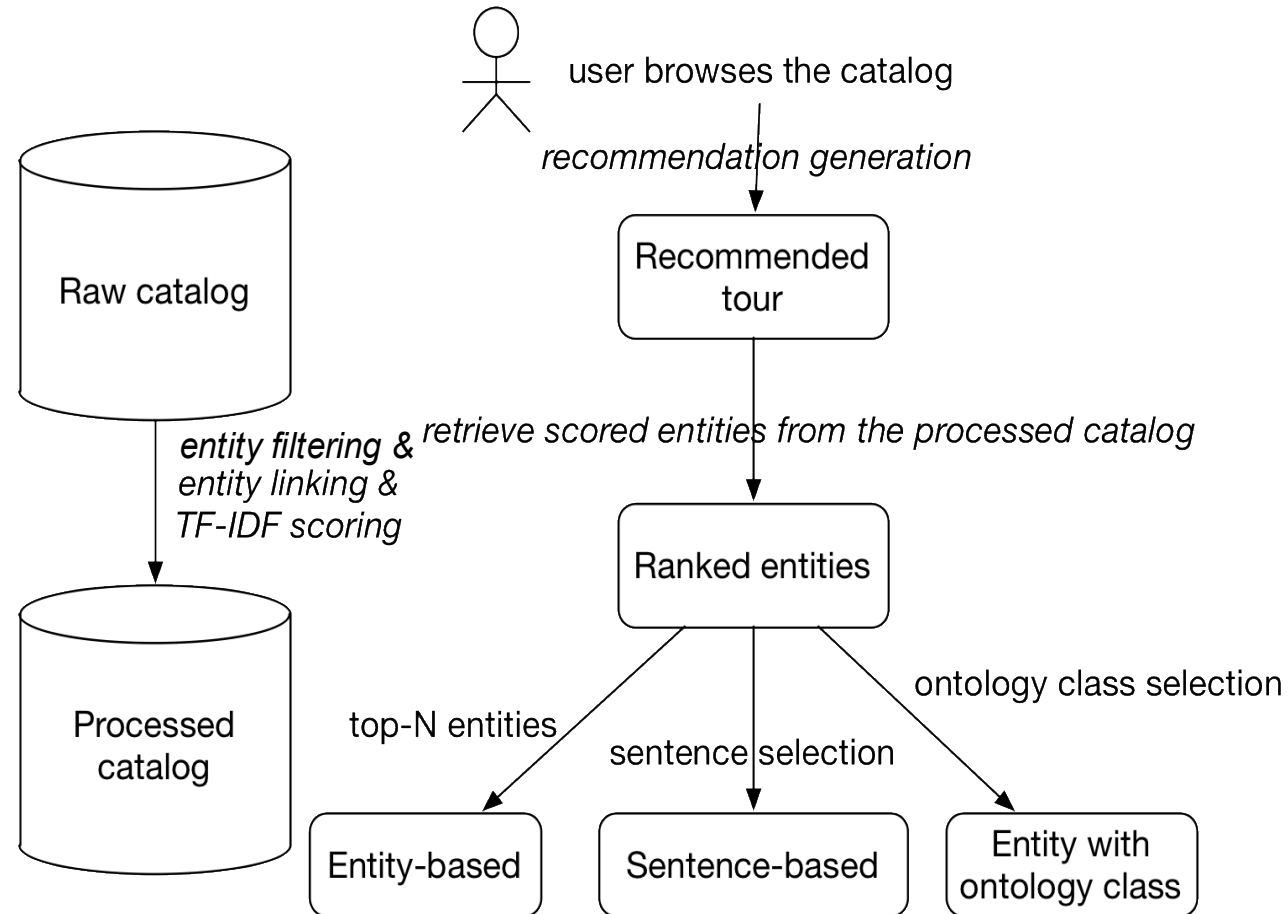
- Given an entity, retrieve its ontology classes
- Select the deepest class in the hierarchy
- E.g. “dbr:Saimaa”, “yago:LakesOfFinland”



# Better user-friendliness with sentence selection

- A sentence-based explanation approach built on two intuitions:
  - Explaining with sentences in natural language is more user-friendly than a mere listing of entities.
  - The more important entities a sentence contains, the stronger the sentence's explanation ability is.
- 3 steps:
  - Entity extraction and scoring
  - Sentence tokenization
  - Sentence scoring

# Better user-friendliness with sentence selection



# Evaluation

- A qualitative user study with 30 participants
- Dataset: a real commercial catalogue of a popular French tour operator containing 1310 tours in 106 countries
- Entity linking resulting in 5,161 distinct entities and 20 per tour
- 4 approaches being compared

<b>Abbreviation</b>	<b>Description</b>
EN	entity-based (baseline)
NL	sentences in natural language
PC	pure class-based (all entities are replaced by classes)
CC	companion class-based (entities are accompanied by classes)



# Evaluation – study design

- Step 1 Participants were asked to put themselves in the scenario of searching for a tour and to imagine a vague travel idea. They select several tours they are interested in.

Please select the travel products which appeal to you and submit your selection by clicking on the button at the bottom of this page.

KAZAKHSTAN , 11 jours

[Le Kazakhstan, une terre mystérieuse](#)

Voyage découverte du Kazakhstan et de ses richesses culturelles et naturelles,

TURQUIE , 8 jours

[La Cappadoce en liberté](#)

Randonnée entre cheminées de fée et vallées au mille couleurs...

EMIRATS ARABES UNIS ,QATAR , 11 jours

[Magie de l'Arabie!](#)

Découverte des sites majeurs du Qatar et des Emirats Arabes Unis.

ISRAEL , 8 jours

[Au coeur du Néguev](#)

randonnée nature au coeur du biblique désert du Néguev et découverte de Massada et Jérusalem

SRI LANKA , 13 jours

[De Colombo à Jaffna](#)

Safari, balades au coeur des montagnes, triangle culturel et Péninsule de Jaffna

INDONESIE , 16 jours

[Belle échappée en Sulawesi \(VTT\)](#)

Découverte en VTT des trésors naturels de Sulawesi : lacs, montagnes et rizières et village ethnique !

EMIRATS ARABES UNIS , 8 jours

[Perles des Emirats](#)

Découverte des Emirats Arabes Unis:Dubaï, Abu Dhabi, oasis de l'Aïn et kayak insolite

BIRMANIE , 14 jours

[Un passeport pour la Terre d'Or!](#)

Classiques de la Birmanie et mini treks dans la région de Loikaw et Mont Victoria

MADAGASCAR , 3 jours

[Trekking à Bekopaka](#)

Rando dans les grands tsingy du Parc de Bemaraha

GUINEE BISSAU , 9 jours

[Bijagos, l'archipel authentique](#)

Odyssée d'île en île dans une nature préservée, sa faune riche, son peuple animiste

FINLANDE , 8 jours

[Vagabondage en Laponie](#)

NAMIBIE , 22 jours

[Total trip en Namibie](#)

Version complète du Kalahari au Fish River Canyon et les chutes d'Epupa entre autres

SAO TOME , 9 jours

[Trek équatorial sur les traces du cacao !](#)

Trek en forêt équatoriale, plantations de café, cacao, visites et plages sauvages !

MALAISIE , 15 jours

[Villages, jungle et eaux turquoises](#)

LE best of de la Malaisie avec l'authenticité en prime

SEYCHELLES , 10 jours

[Douceur des îles en Lodge !](#)

Découverte des Seychelles et de ses 3 parcs marins en hébergements de charme !

# Evaluation – study design

- Step 2 Participants visualise a recommendation banner with 1 tour with some basic information like title, photo, duration and price. The recommendation is accompanied by 4 sets of explanations.



Nordic skiing and pulka in Finnish Lapland  
8 days  
Starting from 1499 €

- Earless seal (Pinnipeds)
  - Saimaa (Lakes of Finland)
  - Art Nouveau (Architectural Styles)
- 

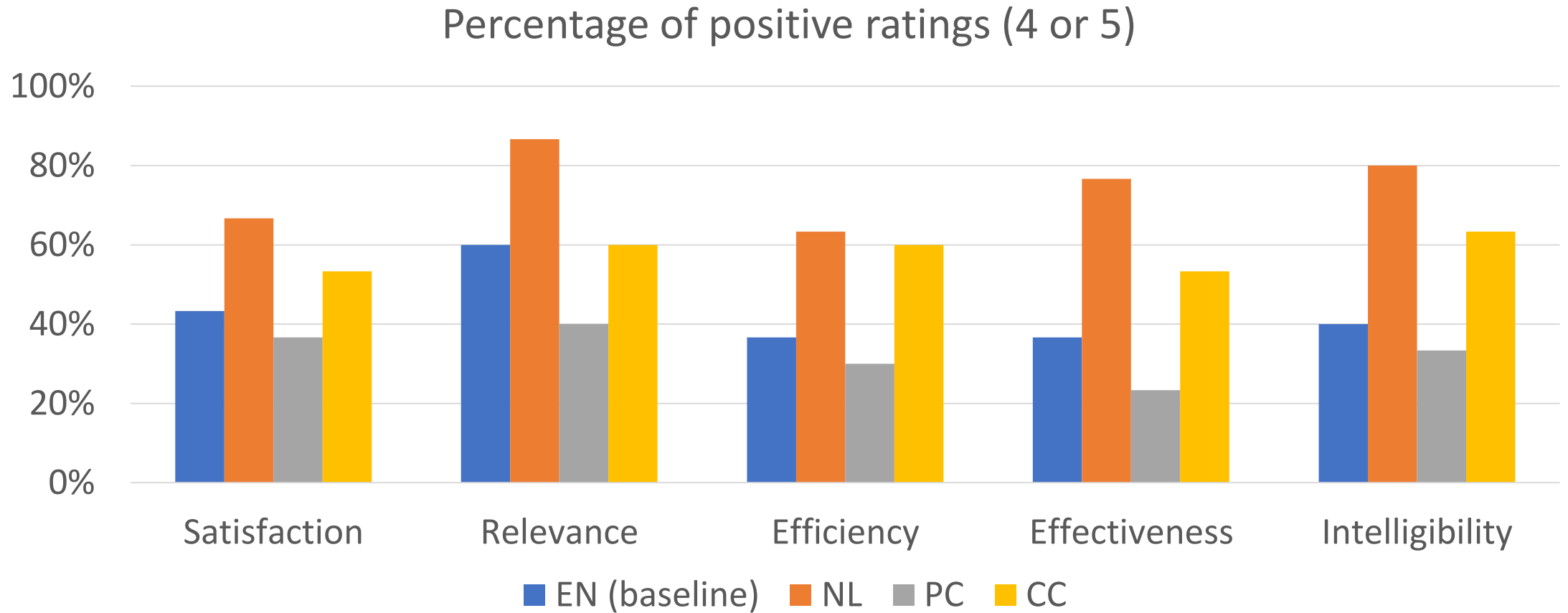
- Clear waters, and a varied wildlife including bears, wolves, bird eagles and the famous and very rare earless seal
- Two hours from Helsinki, Saimaa is the largest lake zone in the country
- In full autonomy, we will leave for 5 days to explore this natural environment and enjoy when we will return the attractions of the capital, between architecture style "art nouveau", green spaces, and omnipresence of the sea

# Evaluation – study design

- Step 3 Participants make a 2-stage judgement. During the first stage, they rate immediately on a five-point Likert scale on the statements related to intelligibility, effectiveness and efficiency. During the second stage, they were asked to read the detailed descriptions of the recommended tour and to rate relevance and satisfaction.

<b>Aspect</b>	<b>Statement</b>	<b>Stage</b>
Intelligibility	The explanation is easy to understand.	1
Effectiveness	The explanation conveys enough information about this tour to help me decide whether to discover more about it or not.	1
Efficiency	The explanation helps me to decide more rapidly whether to discover more about it or not.	1
Relevance	The explanation is relevant to the tour.	2
Satisfaction	Overall I am satisfied with explanation.	2

# Evaluation – results



# Evaluation – results

- The sentence-based approach (NL) outperforms the baseline and achieves high scores on all aspects.
- Better quantity of information to help them understand the recommendation and make decisions more efficiently
- Shortcomings
  - Some sentences are too long.
  - Some sentences contain temporal expressions which do not make much sense without their surrounding sentences.
  - Some sentences are uninteresting as an explanation of the recommendation, e.g. *São Filipe was the name of this island until 1680*
- Results to be viewed cautiously because the approach is dependent on the quality of the textual descriptions. In the travel domain, the descriptions are often well written in order to attract users.

# Evaluation – results

- PC performs slightly worse than the baseline, a simple juxtaposition of classes not appreciated
- CL outperforms the baseline on most of the aspects, better to combine entities with ontology classes than to use entities or classes alone.
- Shortcomings
  - Some entities do not need any additional hint, either self-explanatory e.g. `dbr:World_Heritage_Site` , either very known `dbr:Italy`.
  - Some ontology classes are not interesting enough for explaining the touristic tour. E.g. `dbr:Vienna` has best ranked class `yago:PopulatedPlacesInAustria` while other classes (less profound in the hierarchy) like `yago:WineRegionsOfAustria` and `yago:WorldHeritageSitesInAustria` might be more interesting for the travel domain. This lack of domain interestingness might also partially explain the poor perceived quality of PC.

# Conclusion

- The explanation is an important component in recommender systems. It justifies the recommendation, helps users to better understand it and decide whether to take it or not.
- 3 semantic approaches to alleviate 3 shortcomings of the state-of-the-art approach:
  - Leveraging a DBpedia category tree for filtering out irrelevant entities
  - Increasing the intelligibility of entities with the classes of an integrated ontology
  - Improving the user-friendliness by selecting best sentences from descriptions
- Future work
  - Test the approaches on another travel dataset and other domains
  - Study the personalisation of the explanations