

Enabling Exploratory Search on Manufacturing Knowledge Graphs

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VOILA @ ISWC 22

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What is Exploratory Search?

Exploratory Search

Traditional search systems heavily rely on the popular query-response paradigm.

Lookup-based IR Task

What is the longest river in South America?

🔍

www.eniscuola.net > mediateca > 1... ▾

[10 longest rivers in south America - Eniscuola](#)

10 longest rivers in south America. e-learning. E-learning. To inform younger students about Energy and Environment, Science, Chemistry, English culture and ...

blogpatagonia.australis.com > long... ▾

[What is the longest river in South America?](#)

17.10.2017 — South America boasts no shortage of great rivers. · Stretching somewhere between 6,400 and 6,992 kilometres, the Amazon is South America's ...

en.wikipedia.org > wiki > Amazon... ▾

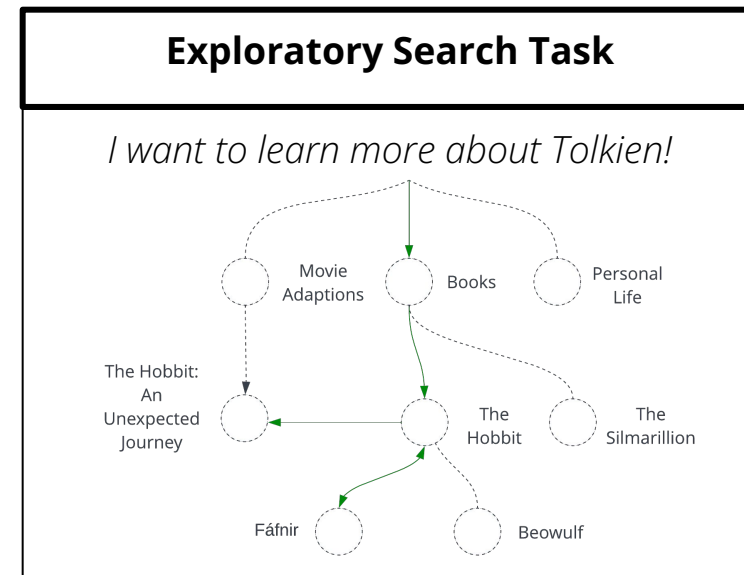
[Amazon River - Wikipedia](#)

The Amazon River in South America is the largest river by discharge volume of water in the world, and the disputed second longest river in the world.

[Origin of the name](#) · [History](#) · [Course](#) · [Watershed](#)

=> successful for well-defined information need with precise goal in mind.

Exploratory search systems enable information seeking tasks such as learning and investigating.

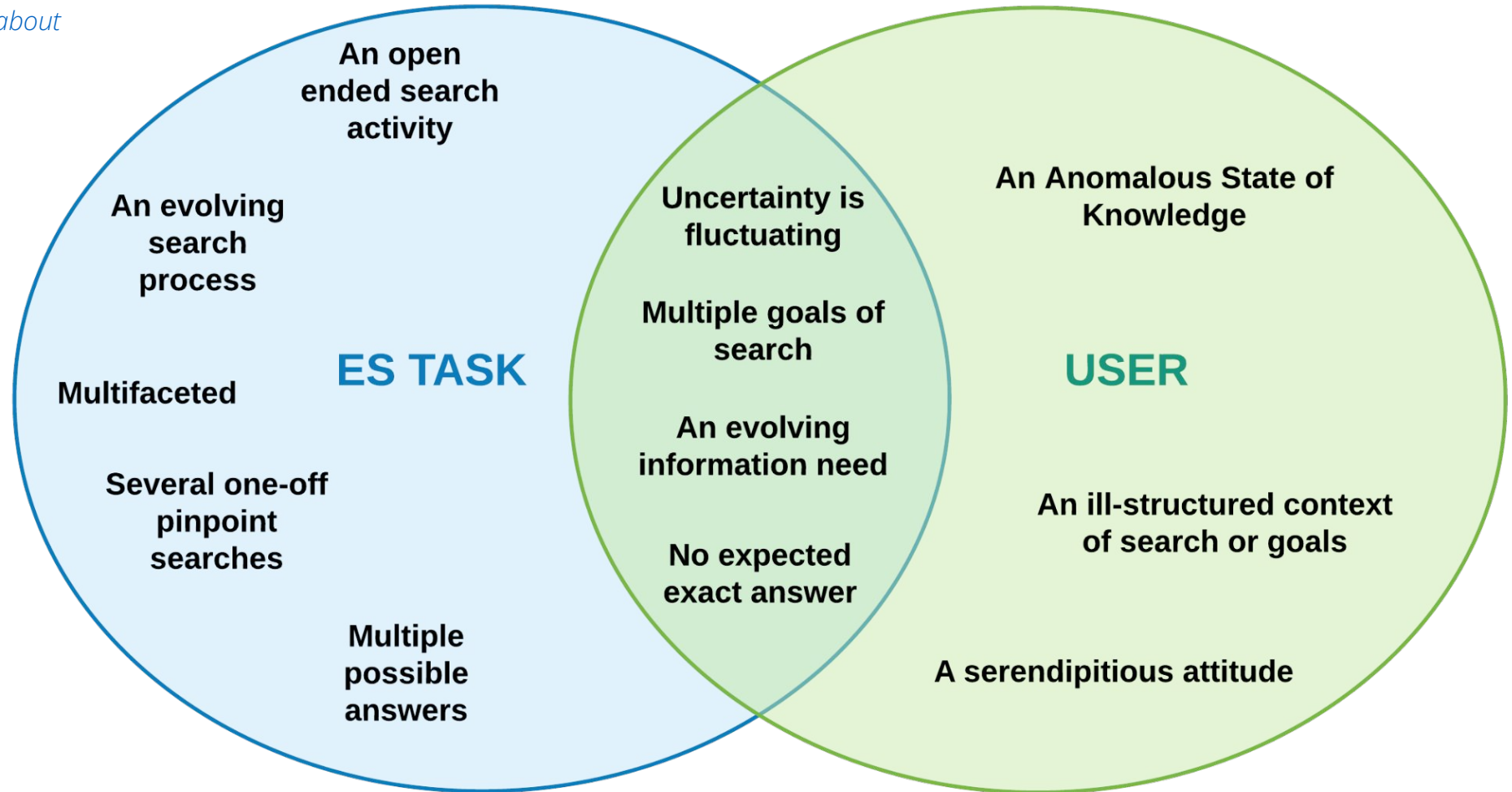
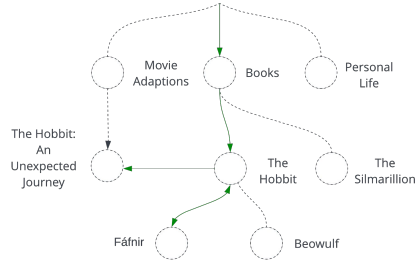


=> increased level of interaction between user and search system

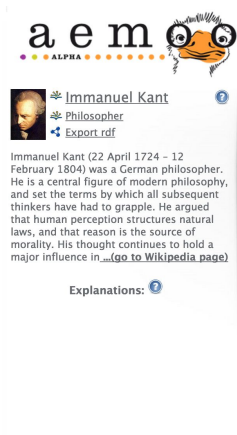
=> more active engagement in search process

Exploratory Search Characteristics

ES Task: I want to learn more about Tolkien!



KG-based Exploratory Search Systems



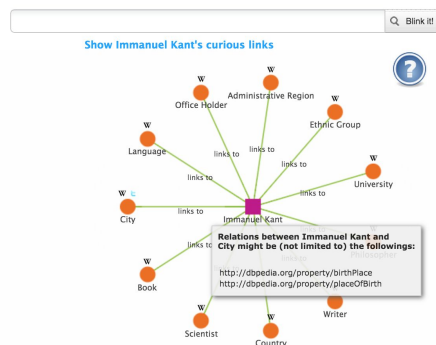
a e m o o
ALPHA

Immanuel Kant
Philosopher
Export rdf

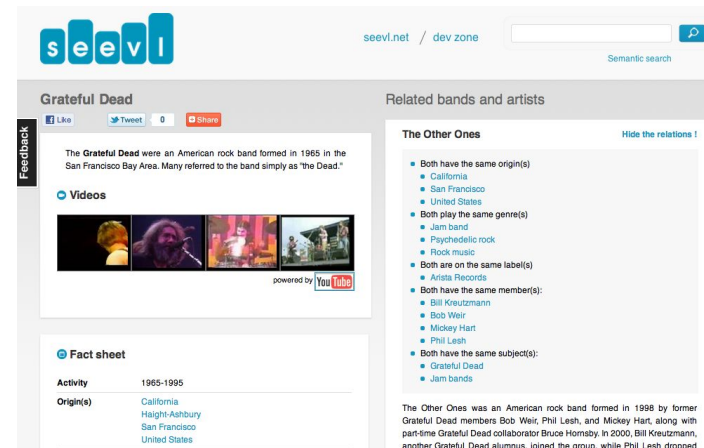
Immanuel Kant (22 April 1724 – 12 February 1804) was a German philosopher. He is a central figure of modern philosophy, and set the terms by which all subsequent thinkers have had to grapple. He argued that human perception structures natural laws, and that reason is the source of morality. His thought continues to hold a major influence in...[\(go to Wikipedia page\)](#)

Explanations: ?

> Immanuel Kant



[Nuz17] **Aemoo**



seevl seevl.net / dev zone

Semantic search

Grateful Dead
Like Tweet 0 Share

The Grateful Dead were an American rock band formed in 1965 in the San Francisco Bay Area. Many referred to the band simply as "the Dead."

Related bands and artists

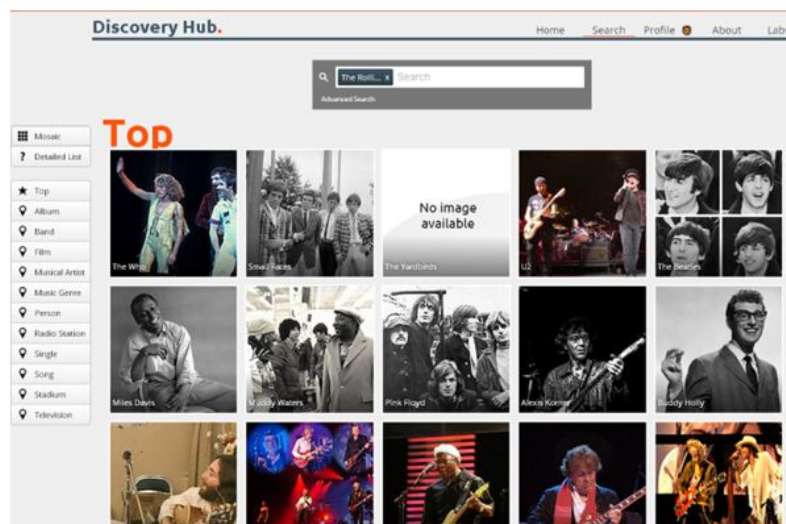
The Other Ones Hide the relations !

- Both have the same origin(s): California, San Francisco, United States
- Both play the same genre(s): Jam band, Psychedelic rock, Rock music
- Both are on the same label(s): Anika Records
- Both have the same member(s): Bill Kreutzmann, Bob Weir, Mickey Hart, Phil Lesh
- Both have the same subject(s): Grateful Dead, Jam bands

Fact sheet

Activity: 1965-1995
 Origin(s): California, Haight-Ashbury, San Francisco, United States

[Pas12] **Seevl**



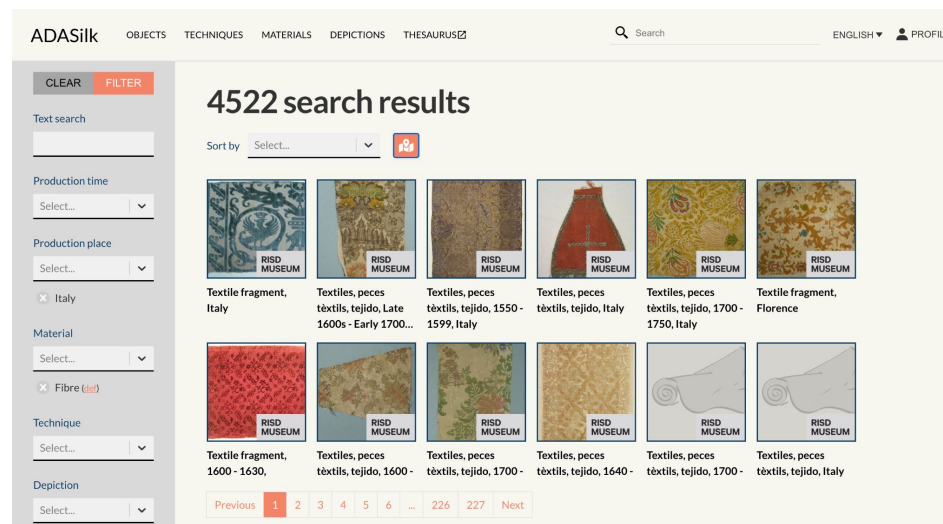
Discovery Hub Home Search Profile About Labs

The Roll... Search

Top

Grid of music-related images: The Who, Dire Straits, The Yardbirds, The Beatles, Miles Davis, Led Zeppelin, Pink Floyd, Alvin Karpis, Buddy Holly.

[Mar13] **Discovery Hub**



ADASIik OBJECTS TECHNIQUES MATERIALS DEPICTIONS THESAURUS

Search ENGLISH PROFILE

4522 search results

Sort by Select...

Grid of textile fragments with descriptions:

- Textile fragment, Italy
- Textiles, pececs tèxtils, tejido, Late 1600s - Early 1700...
- Textiles, pececs tèxtils, tejido, 1550 - 1599, Italy
- Textiles, pececs tèxtils, tejido, Italy
- Textiles, pececs tèxtils, tejido, 1700 - 1750, Italy
- Textile fragment, Florence
- Textile fragment, 1600 - 1630,
- Textiles, pececs tèxtils, tejido, 1600 -
- Textiles, pececs tèxtils, tejido, 1700 -
- Textiles, pececs tèxtils, tejido, 1640 -
- Textiles, pececs tèxtils, tejido, 1700 -
- Textiles, pececs tèxtils, tejido, Italy

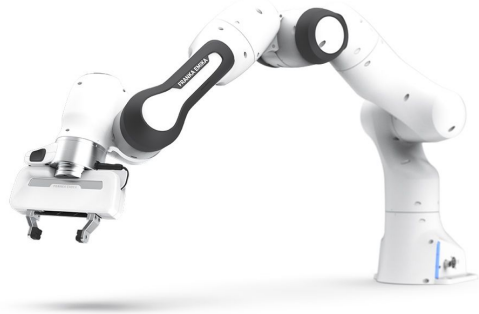
Navigation: Previous 1 2 3 4 5 6 ... 226 227 Next

[Ehr21] **KG Explorer**



What about Manufacturing?

1) Pilotfabrik Aspern - Industrie 4.0



- hosts:
 - collaborative and industrial robotic arms
 - wide range of supporting tools (grippers, sensors, projectors, etc.)

Goal: increase usage degree of equipment by letting students & researchers learn about it.

2) OntoTrans - H2020 EU Project



- Material science and manufacturing domain
- Focus on the translator role

Goal: support in innovation challenge to improve a certain manufactured product in respect to several key performance indicators.



Informal interviews with stakeholders:

- smart manufacturing researchers from industry and university
- translators to companies in OntoTrans
- simulation expert from a production plant manufacturer

=> requirements were aggregated.

Special attention needed for:

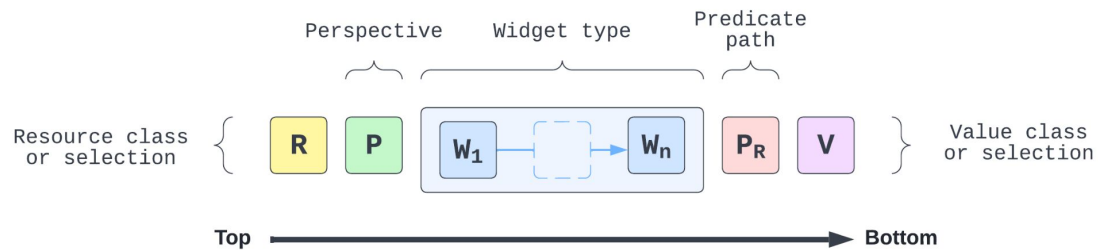
- A) Multiperspectival exploration
=> Proposal: adaptive UI
- B) Provenance visibility
=> Proposal: adaptive UI
- C) Hierarchical browsing
=> Proposal: simple tree view



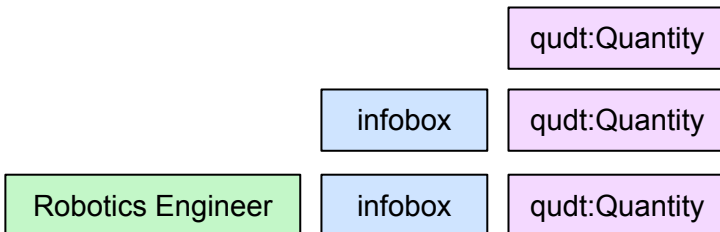
Adaptive UI

- based on the concepts of **Scopes** and **Configurations**
 - introduced by Linked Data Reactor

Scope:



Examples:



Configuration:

```

(10) class = "cobot:RobotType"
(11)
(12) perspective _ widget infobox {
(13)   handler = "GeneralInfoBox"
(14)   config {
(15)     sections = ["prop_table",
(16)                 "recommendations"]
(17)   }
(18) }
(19) perspective _ widget infobox section prop_table {
(20)   handler = "ProvenanceTableSection",
(21)   config {
(22)     neighbourhood {
(23)       include = ["cobot:degreesOfFreedom",
(24)                 "cobot:handlingPayload", "cobot:reach",
(25)                 "cobot:skills"],
(26)     }
(27)   }
(28) }
(29) perspective _ widget infobox {
(30)   property "cobot:reach" {
(31)     handler = "LinkedProperty"
(32)     value _ {
(33)       handler = "TextValue"
(34)     }
(35)     value "qudt:Quantity" {
(36)       handler = "QudtQuantityValue"
(37)     }
(38)   }
(39) }

```

- defining different entry points for exploration

Software Engineer entry

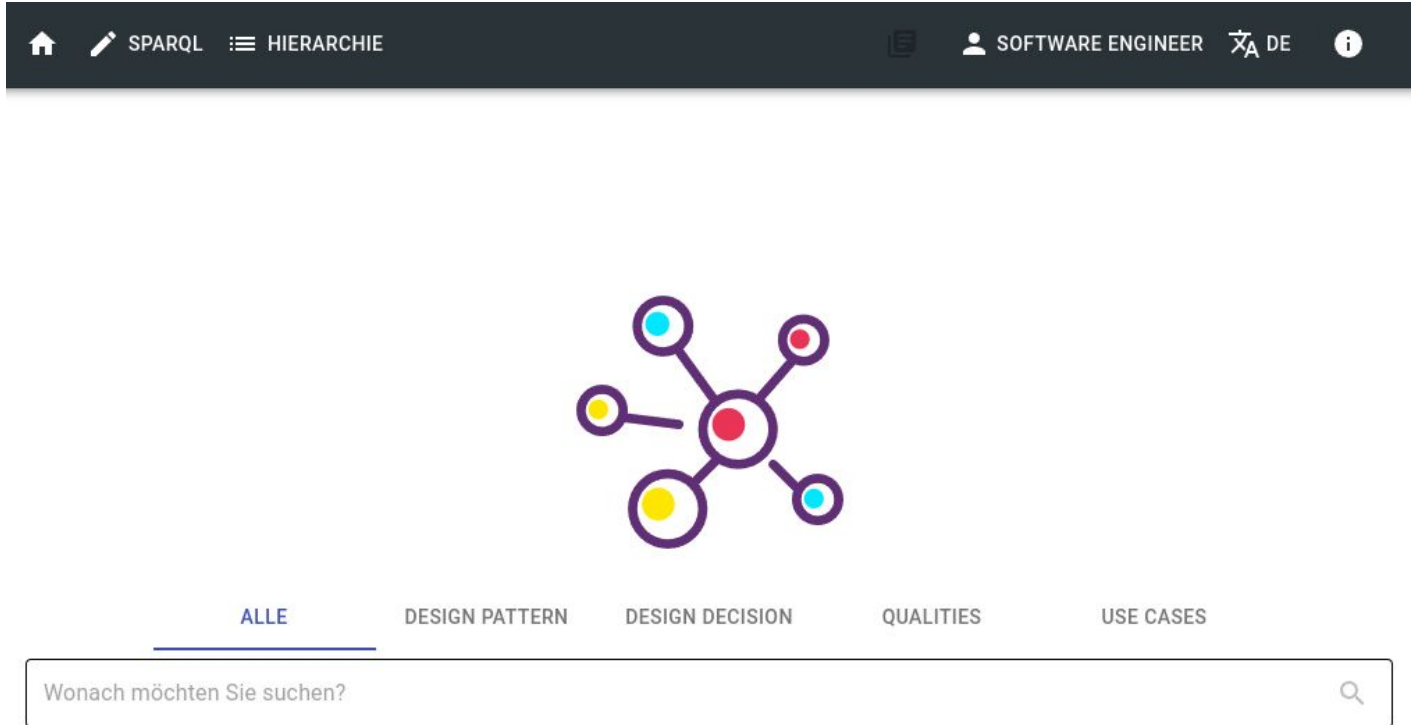
=> search page with relevant categories

Robotics Engineer entry

=> faceted navigation

Knowledge Engineer entry

=> Protégé-like UI



- changing metrics based on perspective


```

(40) perspective _ widget infobox {
(41)   section recommendations {
(42)     handler = "SimilaritySection"
(43)     config {
(44)       number = 4
(45)       ranking = {
(46)         ldsd {
(47)           step = "esm.exploit.sim.ldsd"
(48)           weight = -1.0
(49)         }
(50)       }
(51)     }
(52)   }
(53) }
(54) perspective RoboticsEngineer widget infobox {
(55)   section recommendations {
(56)     config {
(57)       classes = ["cobot:RobotType"]
(58)     }
(59)   }
(60) }
(61) perspective SoftwareEngineer widget infobox {
(62)   section recommendations {
(63)     config {
(64)       classes = ["cobot:HandlingFunction",
(65)                 "star:ArchitecturalElement"]
(66)     }
(67)   }
(68) }

```


UNIVERSAL ROBOTS UR10
RobotType

While the largest robot arm in the UR family and the one with the most muscle power, the UR10 does not compromise on precision. The collaborative robot arm will automate heavier-weight process tasks with payload requirements of up to 10 kg.




Country: [Denmark](#)


Compatible End Effectors:



Schunk Gripper EGA
EndEffectorType
 Electric 2-finger parallel gripper with lightweight profile rail ...



Robotiq Gripper Hand-E
EndEffectorType
 Robotiq's Hand-E Gripper is simple to integrate in your producti ...




Robotiq Gripper 2F-85
EndEffectorType
 The 2F-85 and 2F-140 Adaptive Grippers are the world's best-sell ...


Property Table (Provenance) ⓘ

	Pilot factory interviews	Robot List from Cobotics World
Handling Function	Move, Approach, Depart, Retract	
Skill	Wait, Retrieve, Store	
Reach		1300 mm
Handling Payload		10 kg
Degrees Of Freedom		6


Related Robot Types ⓘ




UNIVERSAL ROBOTS UR5
RobotType
 The slightly bigger UR5 is ideal for automating low-weight proce ...



UNIVERSAL ROBOTS UR3
RobotType
 The UR3 collaborative robot is a smaller collaborative table-top ...



FANUC CR7IA
RobotType
 I'm small, flexible and can work right by your side. I take care ...



KUKA LBR IIWA 7 R800
RobotType
 The LBR iiwa is the world's first series-produced sensitive, and ...



System Architecture

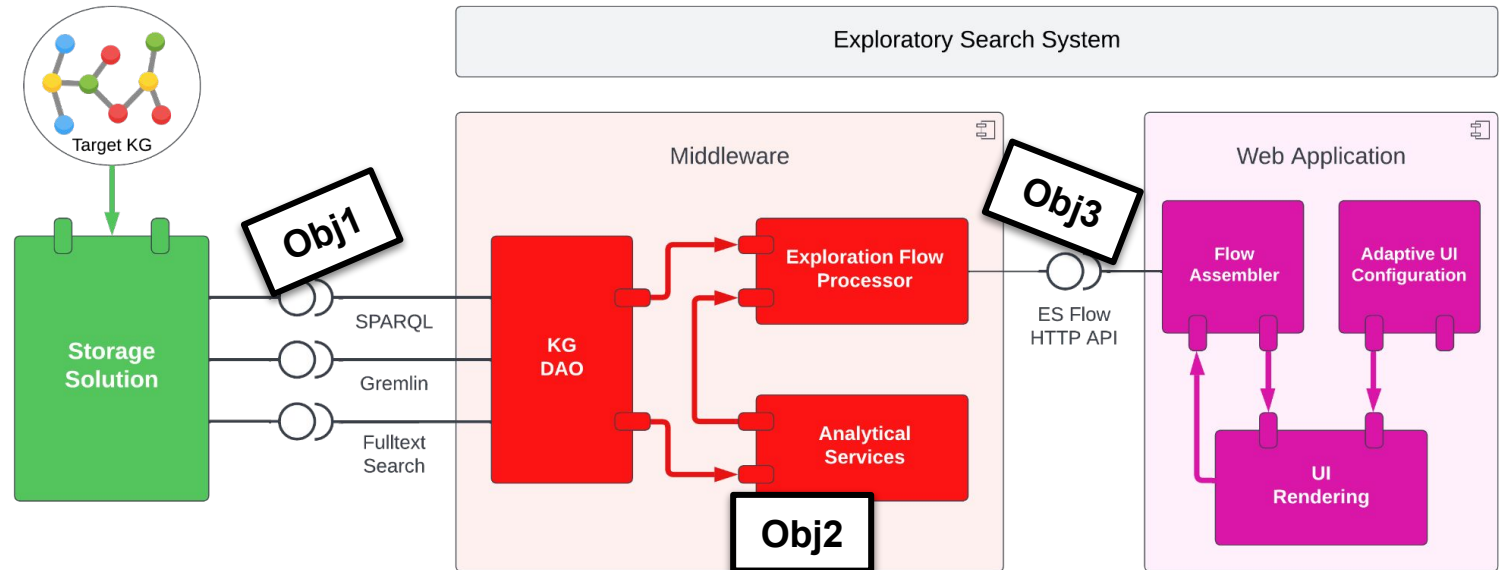
Exploratory Search System Architecture

- Many KG-based ES systems rely only on SPARQL
 - we introduce a middleware

Obj1) adaptable to different legacy environments

Obj2) easily plugin new algorithms for knowledge graph analytics

Obj3) allow experimentation with different interface paradigms



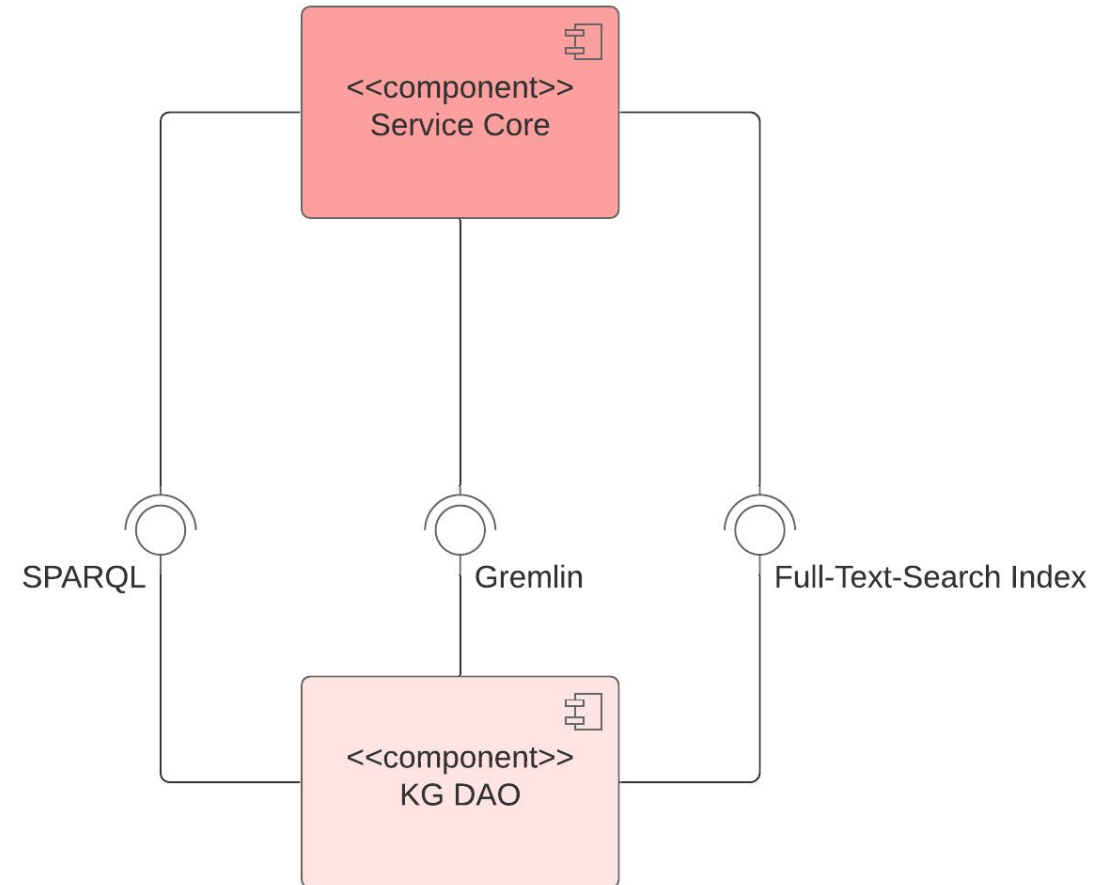
Obj1) Semantic Storage Abstraction

Challenge:

- SPARQL not well suited for some graph algorithms
- No standardized SPARQL feature for full-text searches

=> abstraction of storage solution with three interfaces:

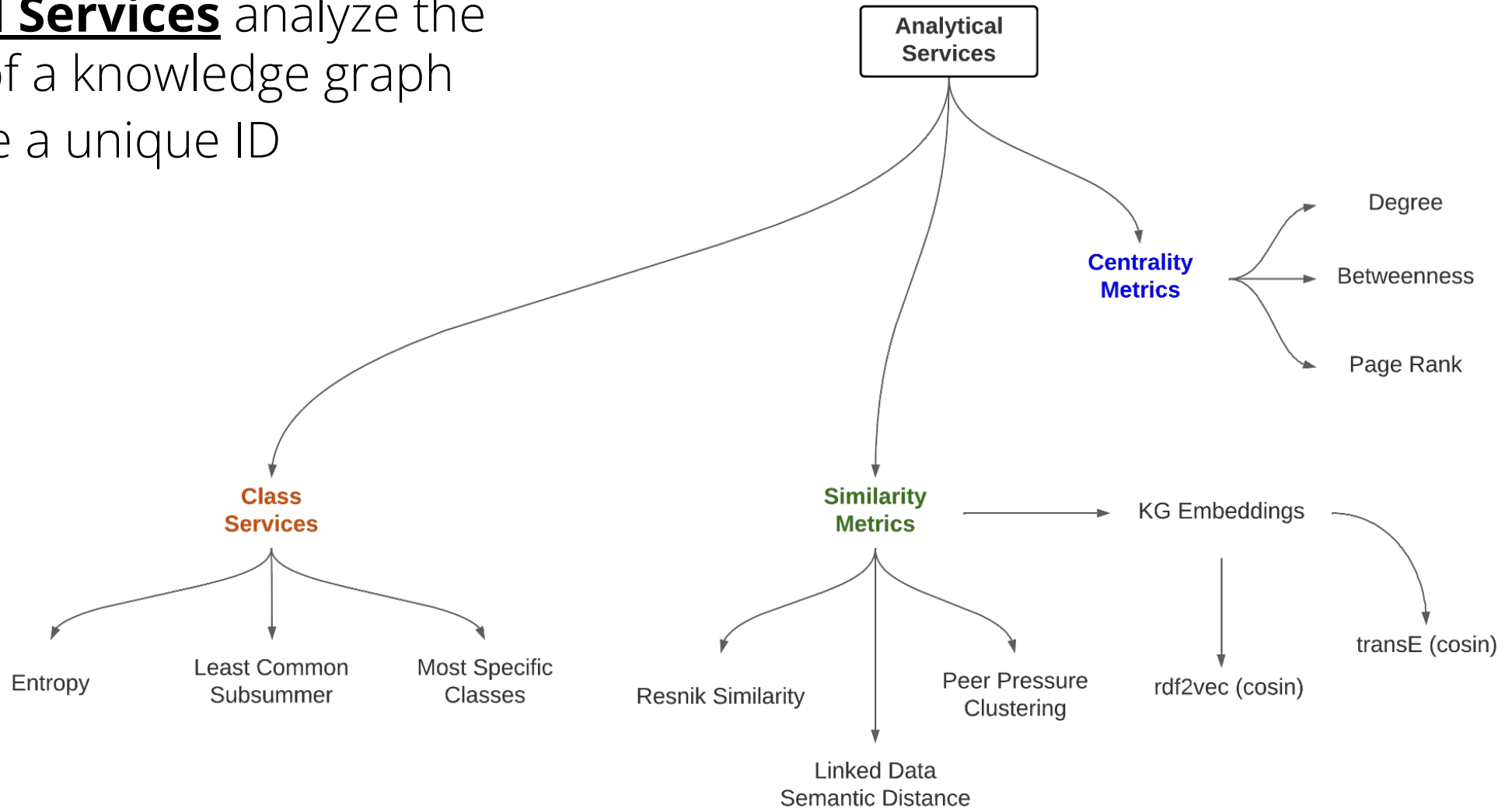
1. SPARQL
2. Gremlin
3. Full-Text-Search Index



Obj2) Analytical Pipeline

Analytical Services analyze the structure of a knowledge graph

- have a unique ID



Obj3) Exploration Flow API

Flow API exposes only the basic concepts of RDF to UI.


- flow = a sequence of steps

```
f = Single(resource='robot:universal-robots-ur10') \
  >> PairWith(flow=All(include=['cobot:RobotType'])) \
  >> LDSD() >> OrderBy(Sim.lsd, strategy=Order.DESC) \
  >> Limit (n=4) >> Describe()
resp = FlowAPI("http://localhost:8080").execute(f)
```






UNIVERSAL ROBOTS UR10
RobotType

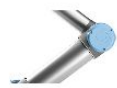



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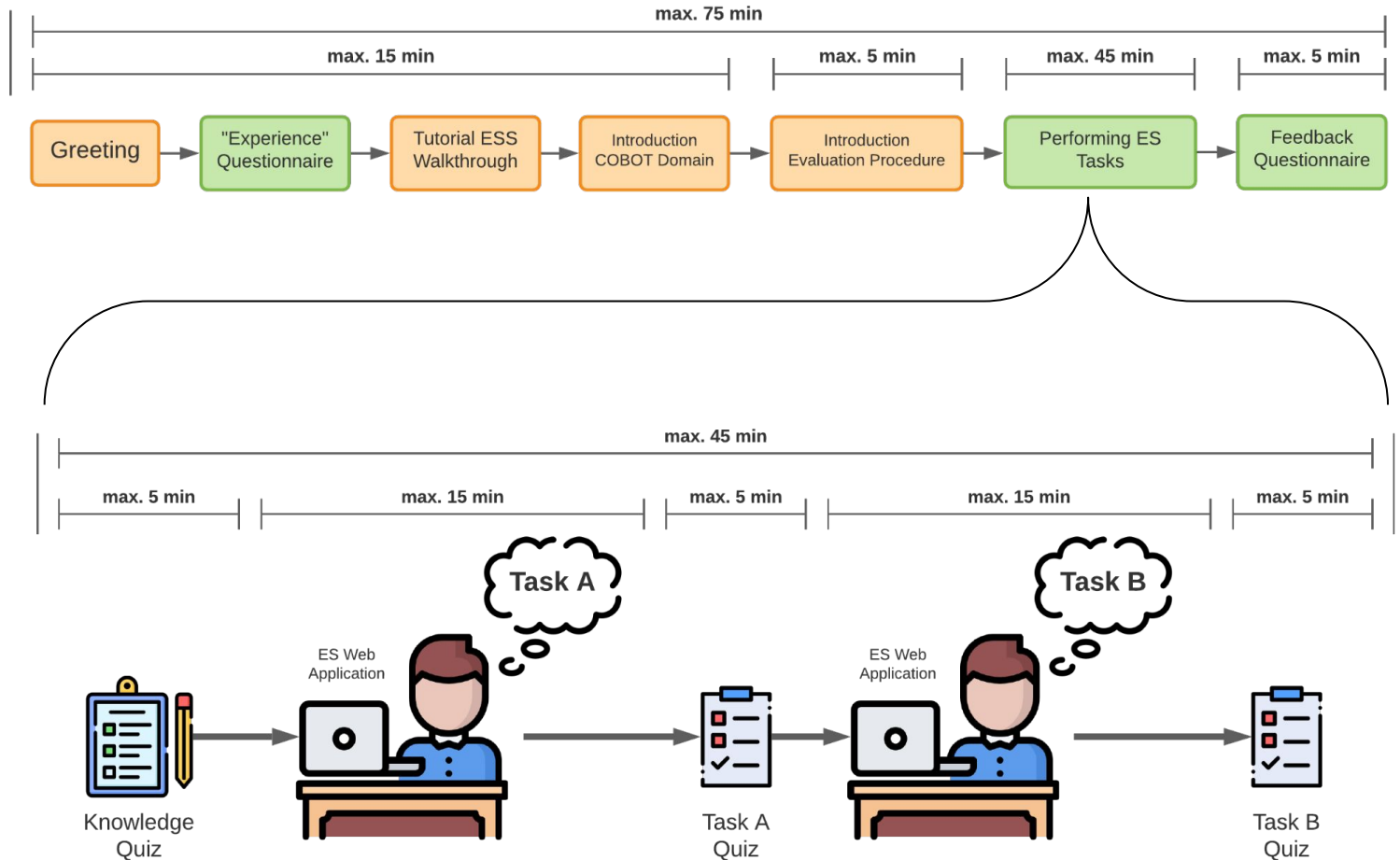
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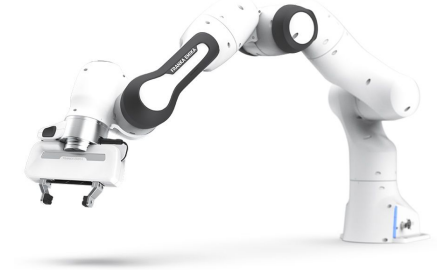


Evaluation

Evaluation Procedure



Exploratory search system applied to a small knowledge graph about cobots and software architectural knowledge.



Outcome:

- Screen recordings
- SUS
- "Usefulness" of certain features
- Knowledge gain



Conclusion

Conclusion

- Participants were able to present reasonable solutions to task
- Issues:
 - memorization feature was ignored in favor of browser tabs
 - tree view had a low click rate and participants struggled with it
- Future work:
 - Evaluation with more participants (>20)
 - RDF-star is a challenge for adaptive UI



Questions?



<https://kevinhaller.dev/papers/22-voila-slides.pdf>

- [Pas12]** Passant, Alexandre. "Seevl: mining music connections to bring context, search and discovery to the music you like." 2012.
- [Mar13]** Nicolas Marie, Fabien Gandon, Myriam Ribière, and Florentin Rodio. 2013. "Discovery hub: on-the-fly linked data exploratory search." In Proceedings of the 9th International Conference on Semantic Systems (I-SEMANTICS '13).
- [Nuz17]** Nuzzolese, Andrea Giovanni, et al. "Aemoo: Linked data exploration based on knowledge patterns." Semantic Web 8.1 (2017): 87-112.
- [Pal18]** Evaluating exploratory search engines: designing a set of user-centered methods based on a modeling of the exploratory search process, Palagi Emelie, PhD Thesis, 2018
- [Ehr21]** Ehrhart, Thibault, Pasquale Lisena, and Raphaël Troncy. "KG Explorer: a Customisable Exploration Tool for Knowledge Graphs." VOILA 2021, International Workshop on the Visualization and Interaction for Ontologies and Linked Data. 2021.