nationale Forschungsdaten Infrastruktur for CULTURE

NFDI MatWerk

NFDI4 DataScience

NFDI formemory

MaRDI

30.01.2024

Knowledge Graph based RDM Solutions

NFDI4Culture, NFDI-MatWerk, NFDI4DataScience und mehr....

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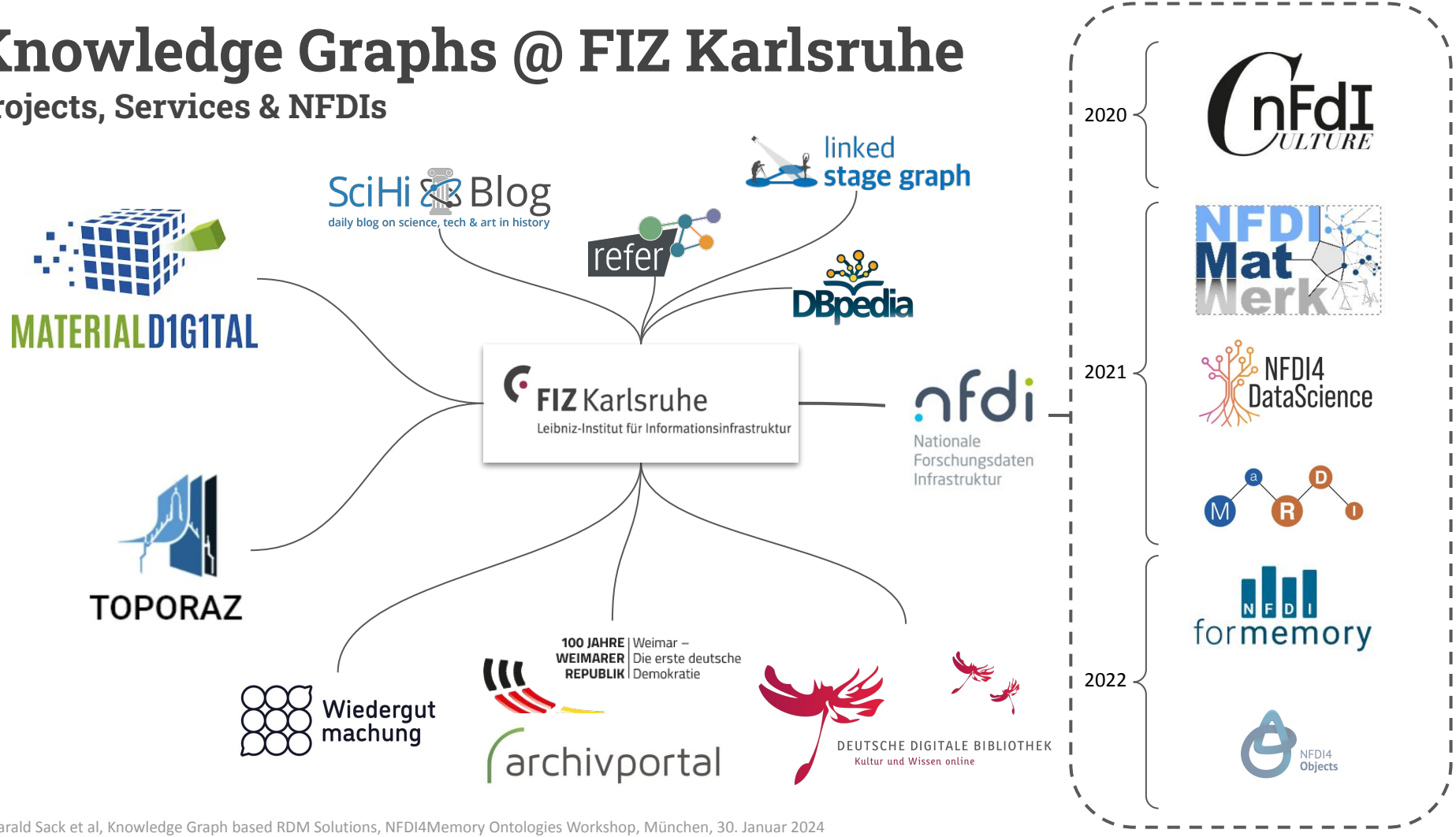
DFG Deutsche Forschungsgemeinschaft

Knowledge Graphs @ FIZ Karlsruhe

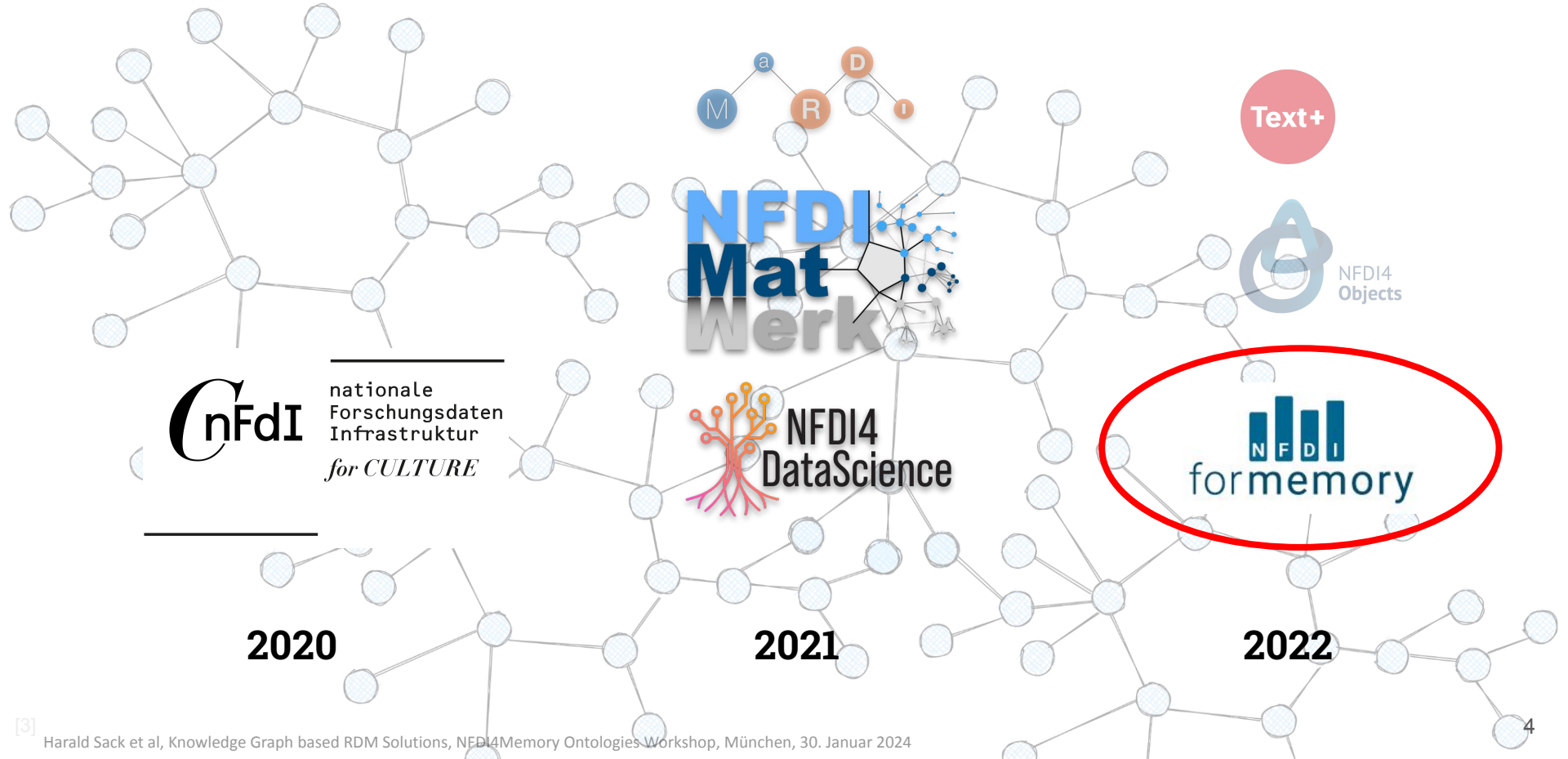
Projects, Services & NFDIs



Starting Point: Information Needs

- (Most) NFDI consortia have rather similar **information needs**
  1. Provision of information **about the consortium** itself, as e.g.,
     - People, organisations, services, resources, etc.
  2. Provision of information about the consortium related **research data,** i.e.
     - (Distributed) **data resources** and (data) **services**

Knowledge Graph(s) as Enabling Technology



[3] Harald Sack et al, Knowledge Graph based RDM Solutions, NFDI4Memory Ontologies Workshop, München, 30. Januar 2024

1. Provision of information about the consortium itself

[3] Harald Sack et al, Knowledge Graph based RDM Solutions, NFDI4Memory Ontologies Workshop, München, 30. Januar 2024

Classes

Creative Work
Intangible
Product
Service
academic discipline
city
collection
consortium
country
data portal
dataset
development work
federal state
license
MIME-type
media type
object type
organization
person
place
programming language
project
provided resource
publication
resource
semantic expressivity
service
service type
software
specification
standard
technological means
website

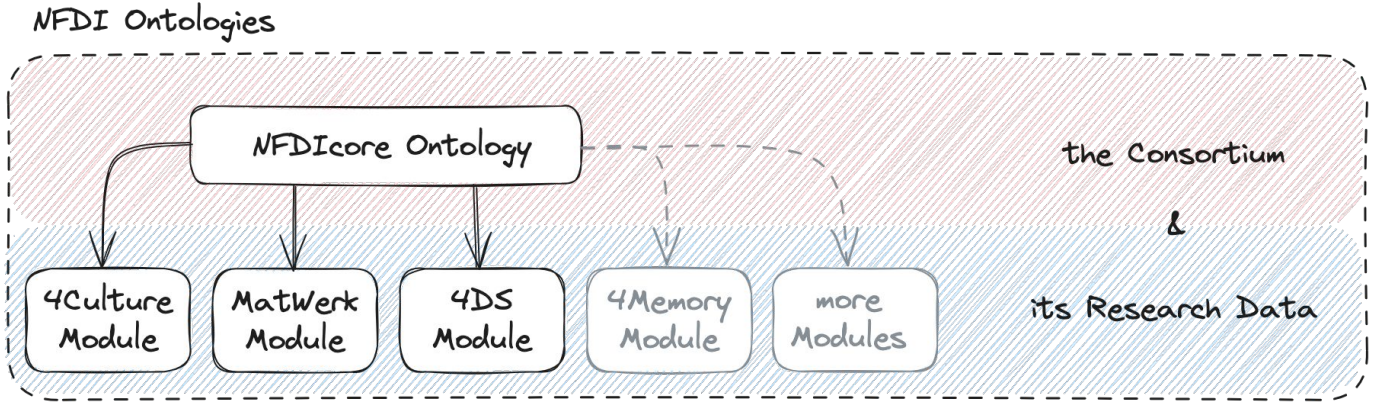
Object Properties

best practice
best practice of
contact point
contact point of
contributor
contributor of
country
country of
export format
export format of
federal state
federal state of
funder
funder of
funding organization
funding organization of

NFDIcore Ontology

(preliminary) namespace:
https://nfdi.fiz-karlsruhe.de/ontology

- NFDI ontologies follow a **modular approach**
- **NFDIcore** represents general NFDI consortia
- **NFDI modules** represent consortium specific information & research data
- NFDIcore 1.1-alpha:
  Reuse of/link to more than 20 popular ontologies & vocabularies:
- dc, bibo, void, hydra, schema.org, fabio, foaf, frapo, obo, skos, wikidata, dbpedia, etc.



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media type
object type
organization
person
place
programming language
project
provided resource
publication
resource
semantic expressivity
service
service type
software
specification
standard
technological means
website

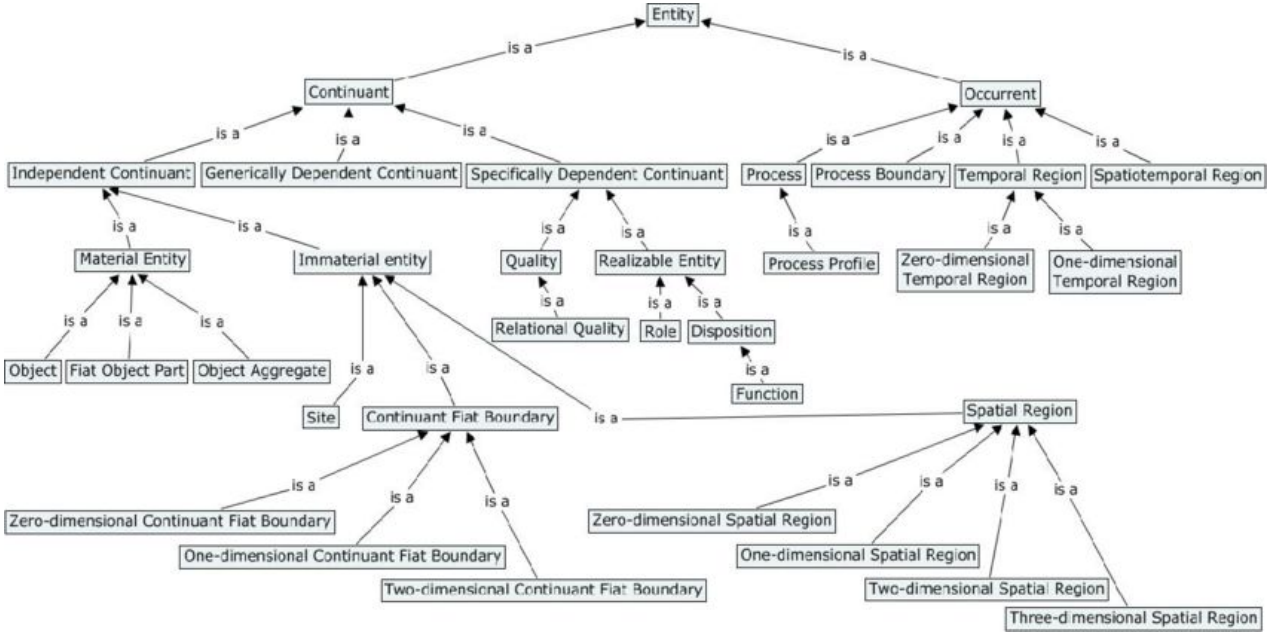
Object Properties

best practice
best practice of
contact point
contact point of
contributor
contributor of
country
country of
export format
export format of
federal state
federal state of
funder
funder of
funding organization
funding organization of

NFDIcore Ontology

(preliminary) namespace:
https://nfdi.fiz-karlsruhe.de/ontology

- NFDIcore 2.0 (NFDIcore-BFO) [mid Feb 2024]:
  - **Fully BFO compliant** (Basic Formal Ontology)
  - while maintaining the original structure for **ease of use**



Classes

AcademicDiscipline Authority AuthorityType BestPractice City CollectionOrDataset Contribution ControlledVocabulary Country DataPortal DevelopmentWork FederalState InstanceOfRDMTool License Mapping MediaType Norm ObjectType Ontology OntologyType Organization Person Place ProgrammingLanguage Project Publication RDMInfrastructure RDMService RDMTool Service ServiceType Software SparqlEndpoint Specification Technology Website

AcademicDiscipline

IRI	https://nfdi4culture.de/ontology#AcademicDiscipline
label	academic discipline
description	An academic discipline, a research field or domain of a resource, e.g. a data portal.
type	owl:Class
subClassOf	fabio:SubjectDiscipline modsci:Science dbo:AcademicSubject
example	Architecture, Art History, Musicology, Media Studies, Performing Arts wikidata:Q12271

Authority

IRI	https://nfdi4culture.de/ontology#Authority
label	authority
description	A collection of selected decisions or rules for a form of entry that result in the consistency of entries to improve interoperability and retrieval of data.
type	owl:Class
subClassOf	schema:Product
example	Art & Architecture Thesaurus, Gemeinsame Norm Datei, Cultural Objects Names Authority
equivalentClass	fabio:AuthorityFile

AuthorityType

IRI	https://nfdi4culture.de/ontology#AuthorityType
label	authority type
description	The type of an authority used for the establishment and maintainance of consistent forms of terms.
type	owl:Class
example	Thesaurus, Authority File, Authority List

NFDI4Culture Ontology

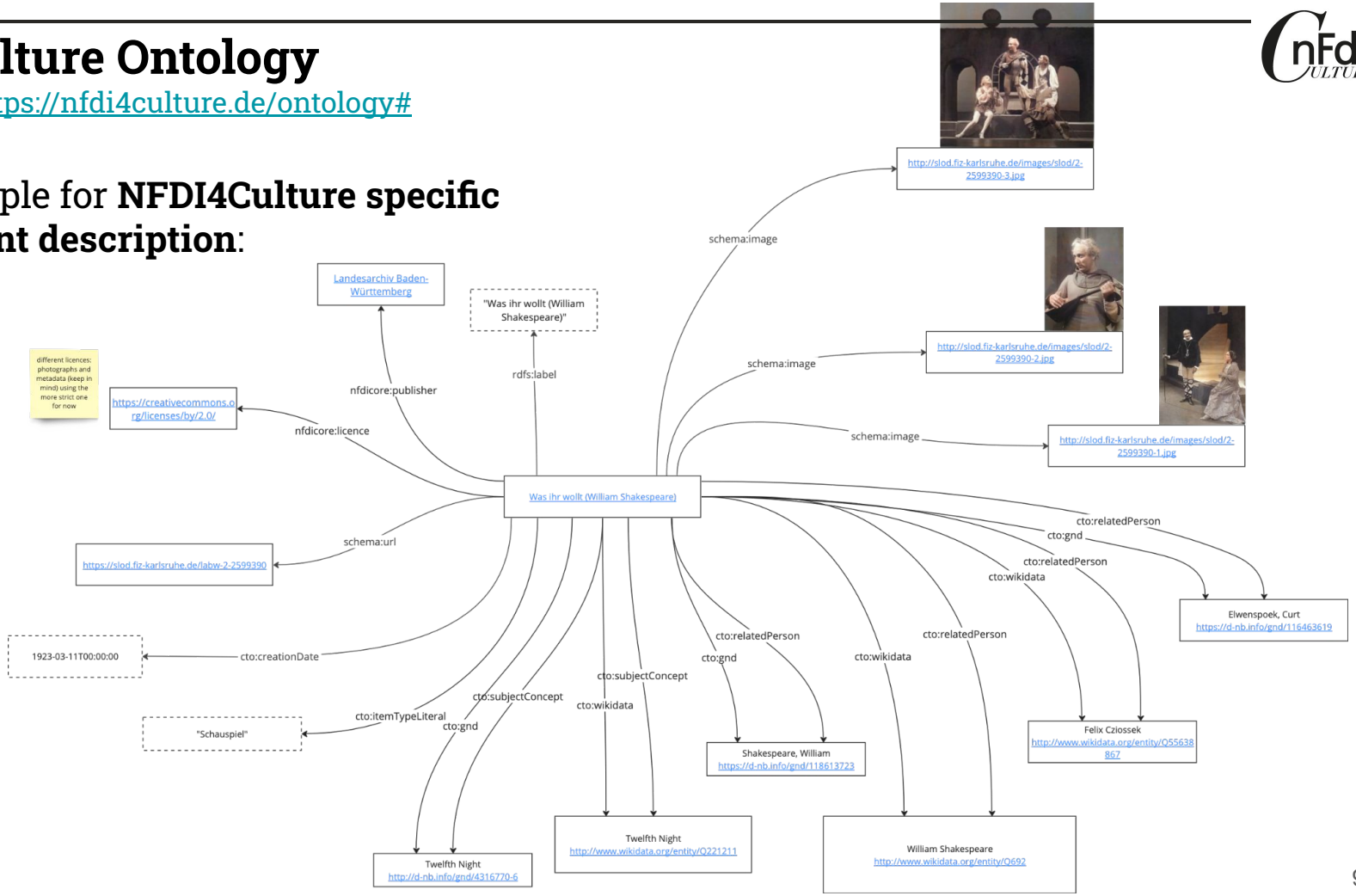
namespace: https://nfdi4culture.de/ontology#

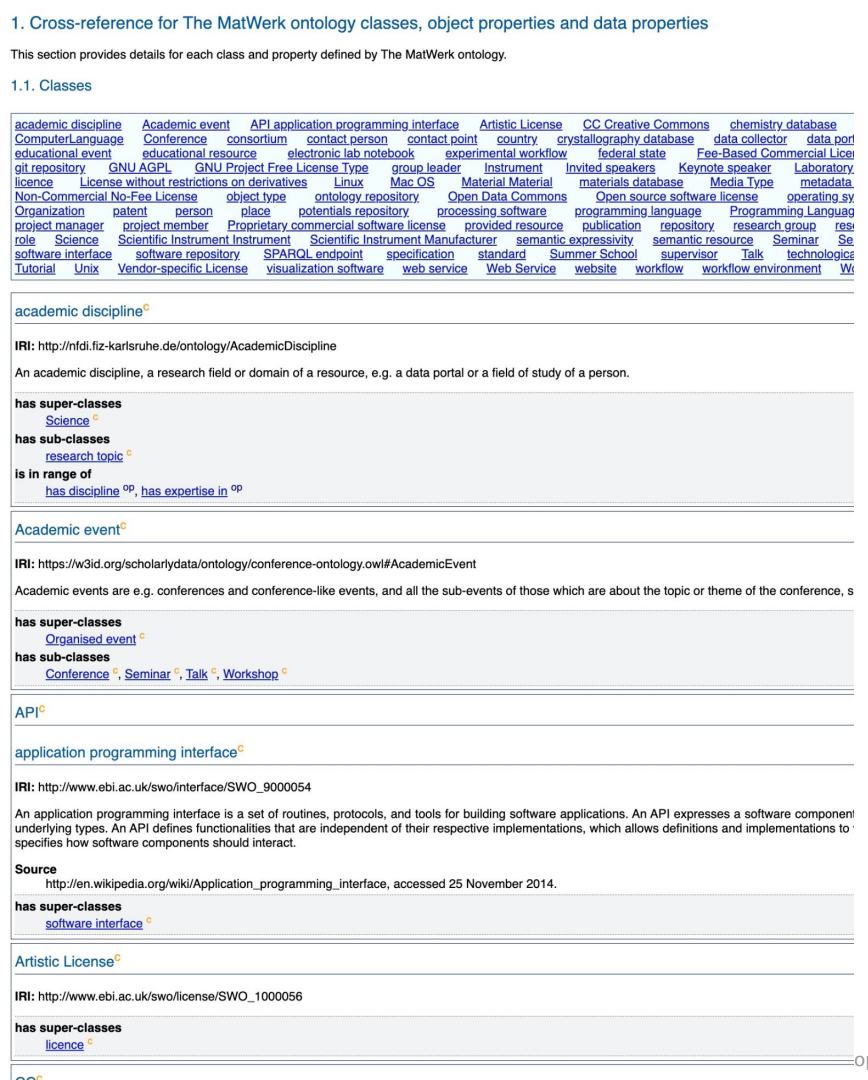
- Represents **resources of NFDI4Culture**, e.g.
  a. (NFDIcore) community structure:
  people, projects, organisations, etc.
  b. (NFDIcore) infrastructure:
  services, software, APIs, guidelines, educational resources, etc.
  c. (NFDIcore) data:
  repositories, datasets, scientific publications, etc.
  d. content (recent development):
  objects, persons, locations, events, mappings, etc.
- Contains 36 classes and 63 relations
- New version released in Feb 2024

NFDI4Culture Ontology

namespace: https://nfdi4culture.de/ontology#

- Example for **NFDI4Culture specific content description**:





1. Cross-reference for The MatWerk ontology classes, object properties and data properties

This section provides details for each class and property defined by The MatWerk ontology.

1.1. Classes

academic discipline Academic event API application programming interface Artistic License CC Creative Commons chemistry database ComputerLanguage Conference consortium contact person contact point country crystallography database data collector data port educational event educational resource electronic lab notebook experimental workflow federal state Fee-Based Commercial Licer git repository GNU AGPL GNU Project Free License Type group leader Instrument Invited speakers Keynote speaker Laboratory licence License without restrictions on derivatives Linux Mac OS Material Material materials database Media Type metadata Non-Commercial No-Fee License object type ontology repository Open Data Commons Open source software license operating sy Organization patent person place potentials repository processing software programming language Programming Languag project manager project member Proprietary commercial software license provided resource publication repository research group res role Science Scientific Instrument Instrument Scientific Instrument Manufacturer semantic expressivity semantic resource Seminar Se software interface software repository SPARQL endpoint specification standard Summer School supervisor Talk technologica Tutorial Unix Vendor-specific License visualization software web service Web Service website workflow workflow environment W

academic discipline[C]

IRI: http://nfdi.fiz-karlsruhe.de/ontology/AcademicDiscipline

An academic discipline, a research field or domain of a resource, e.g. a data portal or a field of study of a person.

has super-classes
Science [C]
has sub-classes
research topic [C]
is in range of
has discipline [OP], has expertise in [OP]

Academic event[C]

IRI: https://w3id.org/scholarlydata/ontology/conference-ontology.owl#AcademicEvent

Academic events are e.g. conferences and conference-like events, and all the sub-events of those which are about the topic or theme of the conference, s

has super-classes
Organised event [C]
has sub-classes
Conference [C], Seminar [C], Talk [C], Workshop [C]

API[C]

application programming interface[C]

IRI: http://www.ebi.ac.uk/swo/interface/SWO_9000054

An application programming interface is a set of routines, protocols, and tools for building software applications. An API expresses a software component underlying types. An API defines functionalities that are independent of their respective implementations, which allows definitions and implementations to specifies how software components should interact.

Source
http://en.wikipedia.org/wiki/Application_programming_interface, accessed 25 November 2014.

has super-classes
software interface [C]

Artistic License[C]

IRI: http://www.ebi.ac.uk/swo/license/SWO_1000056

has super-classes
licence [C]

NFDI-MatWerk

namespace: http://purls.helmholtz-metadaten.de/mwo/

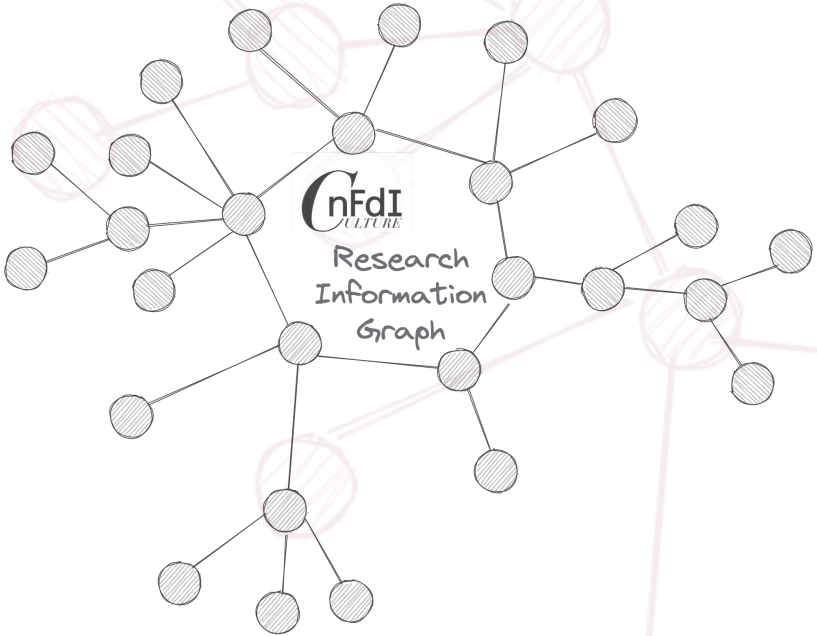
- Represents **resources of NFDI-MatWerk**:
  a. (NFDIcore) community structure: **researchers**, **research projects**, **universities**, **institutions**, etc.
  b. (NFDIcore) infrastructure: software, ontologies, schemas, APIs, **instruments**, **facilities**, educational resources, etc.
  c. (NFDIcore) data: repositories, **databases**, scientific publications, published datasets and **reference data**, etc.
  d. **content (tbd): workflows, materials, infrastructure, mappings, persons, events**
- Contains 115 classes and 103 relations

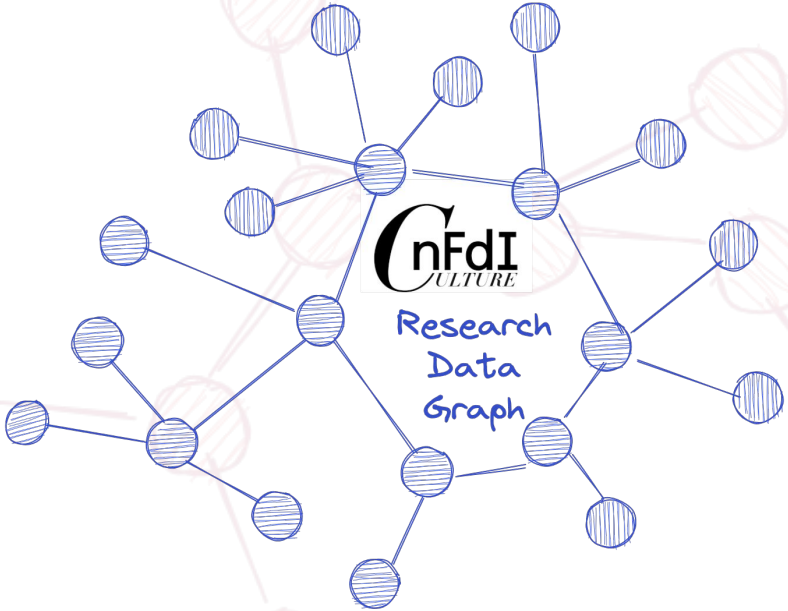
NFDIxxx Knowledge Graphs

- **Central connecting element** of all NFDI consortium resources
- Consists of
  - **Research Information Graph** (information about consortium)
  - **Research Data Graph** (information about research data)
- Serves as **backend** for Web Information Portal
- Enable **discovery** of and **federation** over research data
- Enable **connectivity** to other NFDI consortia and external resources

[3] Harald Sack et al, Knowledge Graph based RDM Solutions, NFDI4Memory Ontologies Workshop, München, 30. Januar 2024

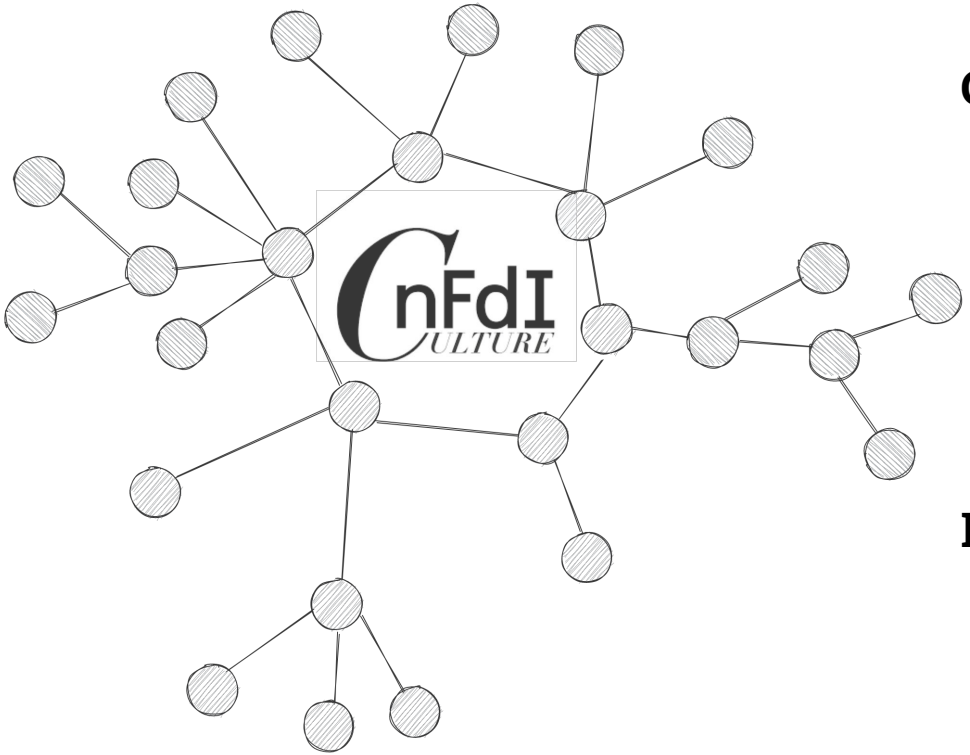
Example: NFDI4Culture KG





Research Information Graph + Research Data Graph = NFDI4Culture KG

NFDI4Culture-KG Research Information Graph



Content:

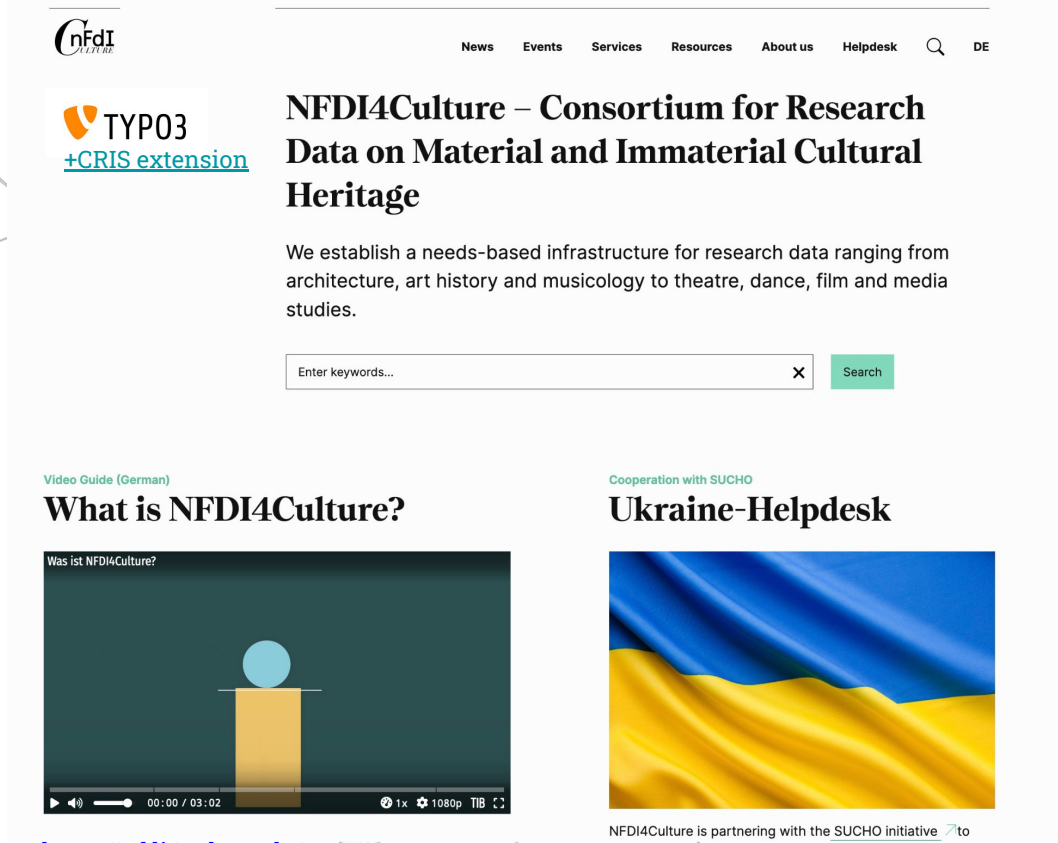
- Index and Metadata for
  - NFDI4Culture Project Resources
  - Persons and Institutions
  - Expertises
  - Data Resources
  - Data Services

Purpose:

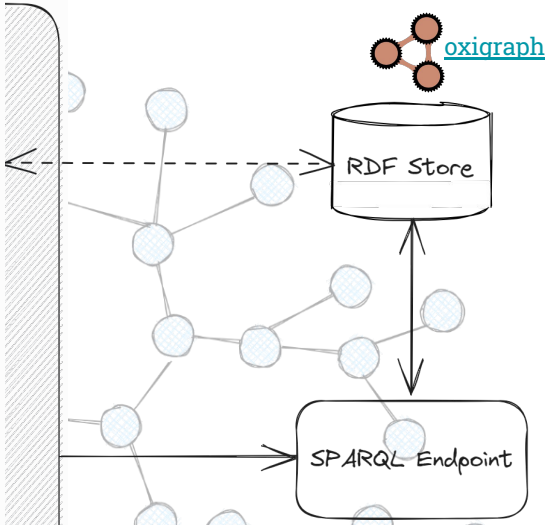
- Backend (Meta-)Data Resource for the **NFDI4Culture Portal** (https://nfdi4culture.de/)

Public SPARQL Endpoint:
https://nfdi4culture.de/resources/knowledge-graph.html

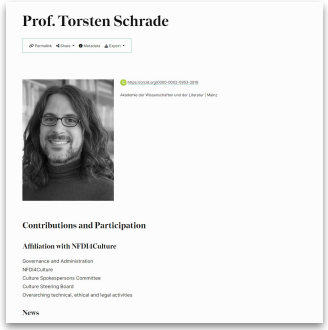
NFDI4Culture Portal

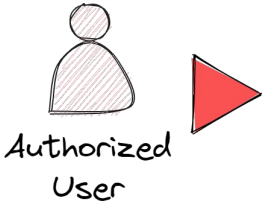


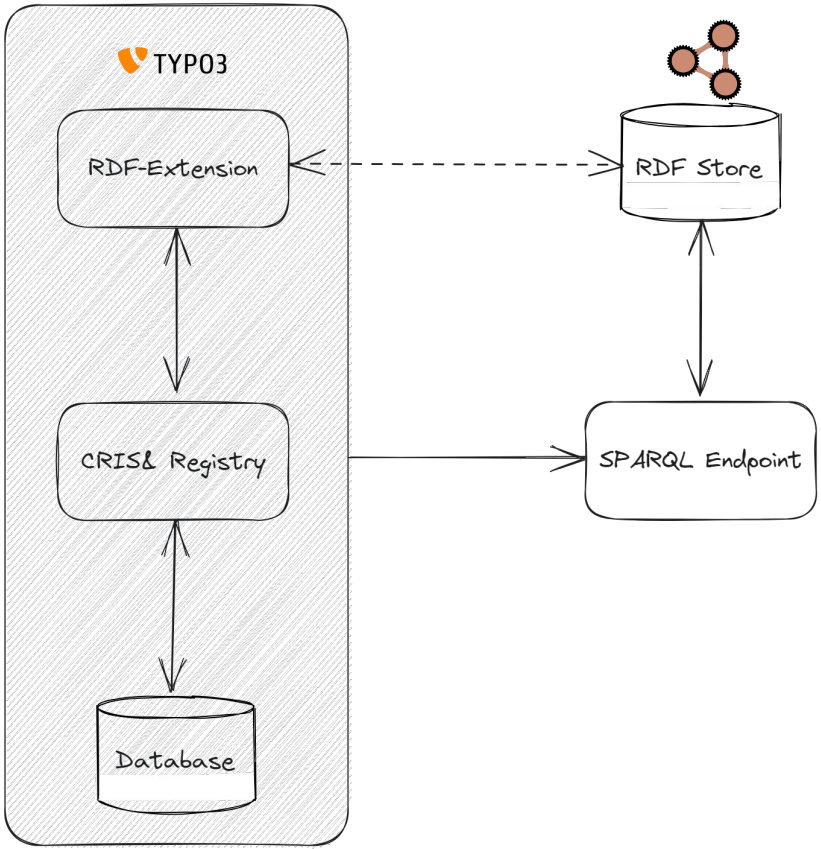
https://nfdi4culture.de/



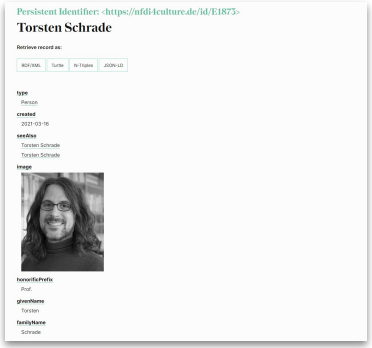
NFDI4Culture Portal



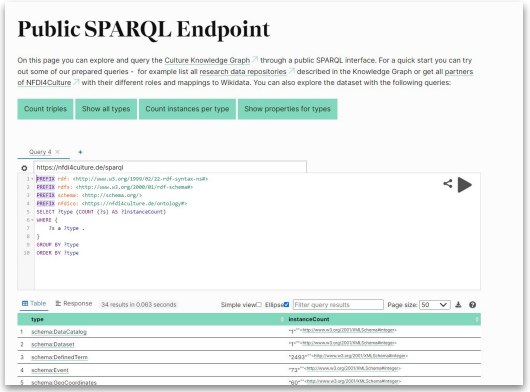




https://nfdi4culture.de/



https://nfdi4culture.de/id/E1873



https://nfdi4culture.de/sparql

NFDI4Culture KG Dashboard

Culture Consortium Dashboard

NFDI4Culture Dashboard

Total data (all consortium partners)

107,182,233

data items in consortium / 2024-01-26

Culture Knowledge Graph

27,158,095

statements about items

Culture Information Portal

3,519,421

curated metadata items

Data providers in consortium

34

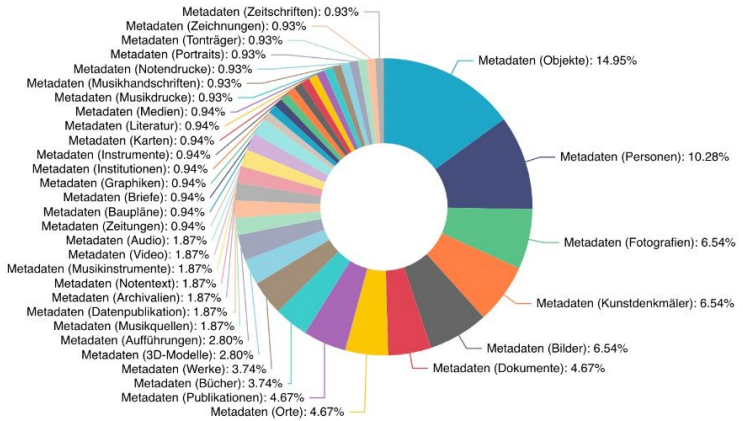
contributing partners

Data services in consortium

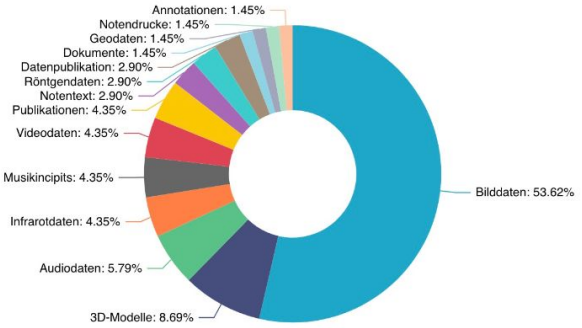
69

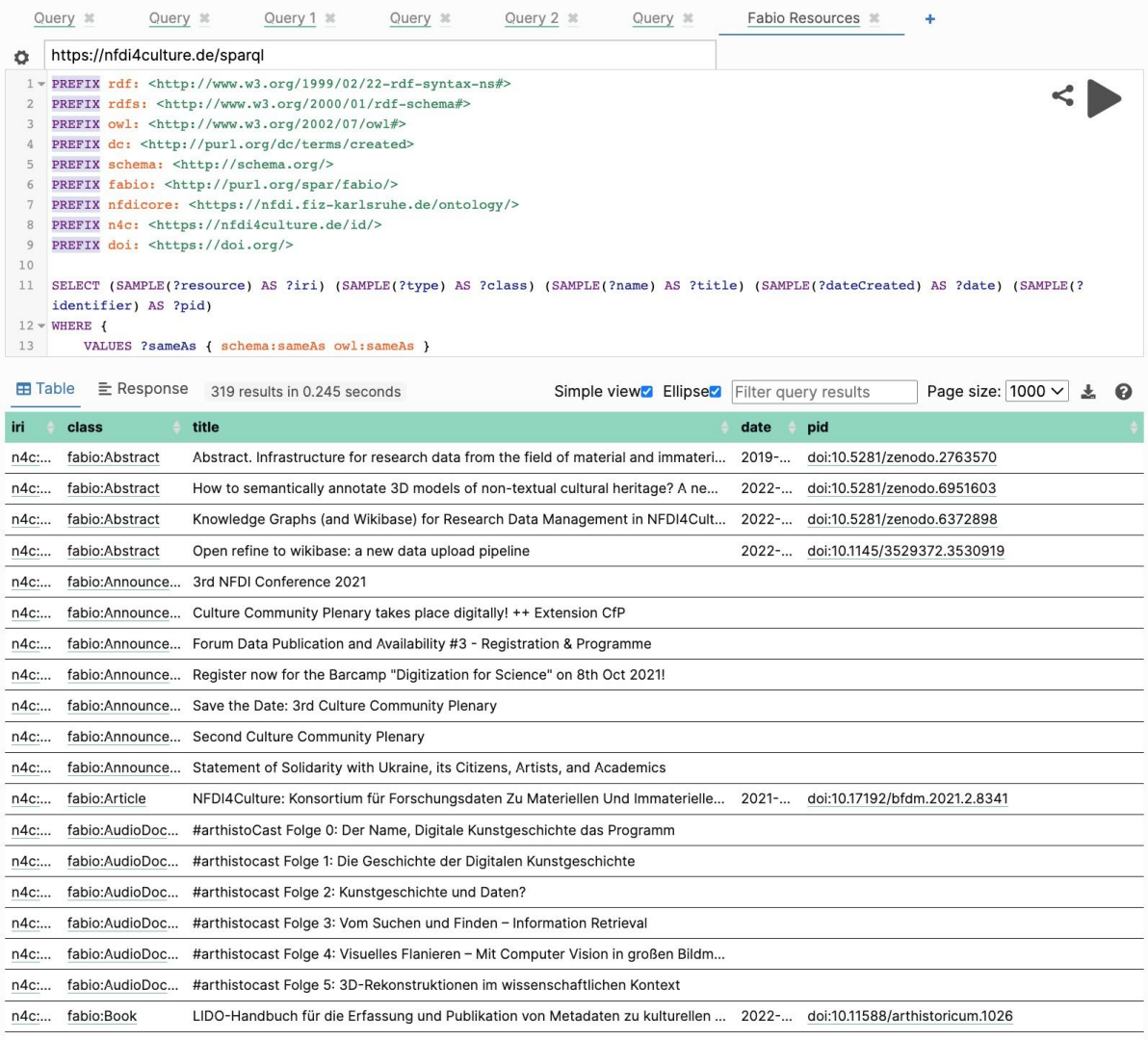
registered data portals

Types of metadata (distribution accross data portals)



Types of data (distribution accross data portals)



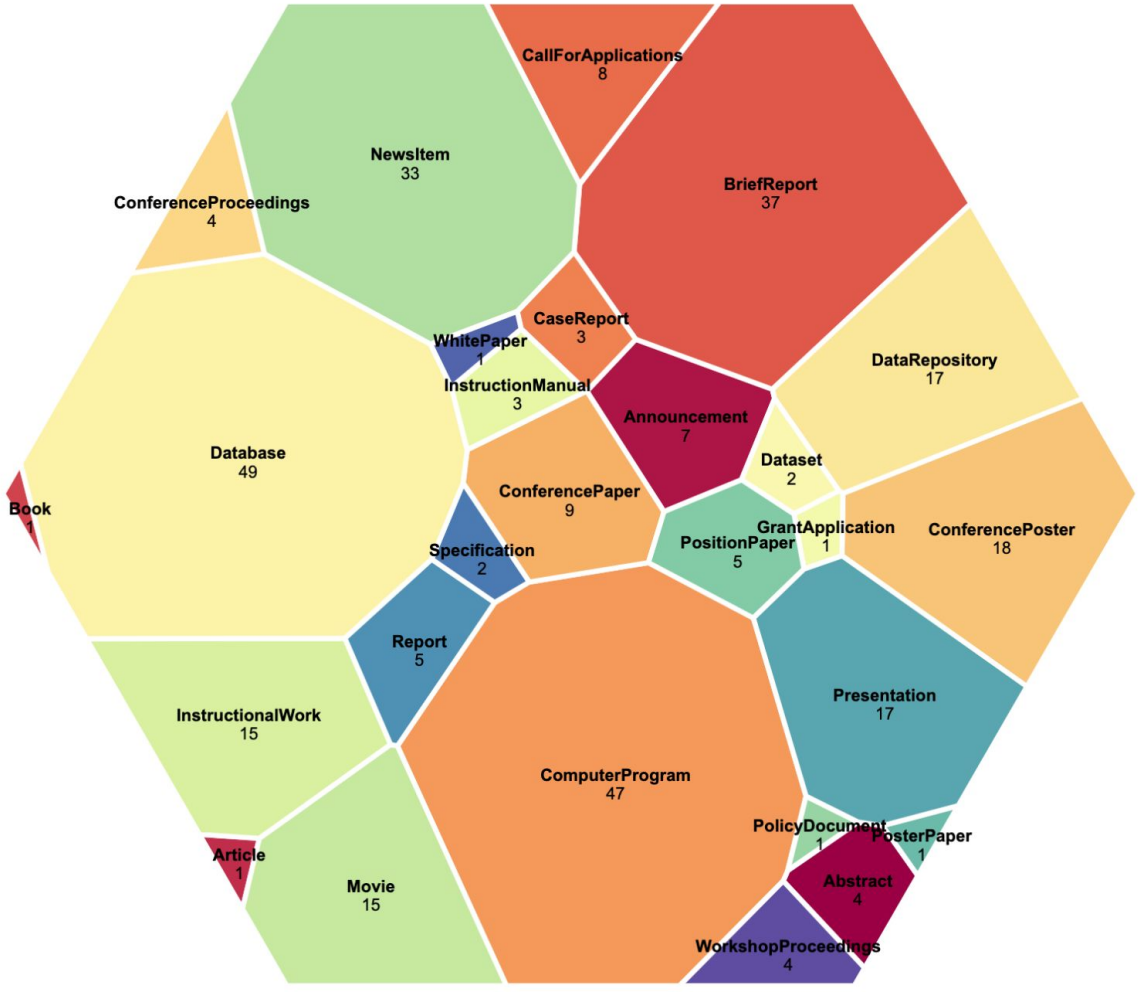


SPARQL Endpoint Data Exploration

1. *List all **publications** of NFDI4Culture **for the progress report aligned to FaBIO***
2. List all **other NFDI consortia** in which NFDI4Culture members are involved in **for the progress report** (via federation with Wikidata)

SPARQL Query

SPARQL Endpoint Data Exploration



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SPARQL Query

Query ✖ Query ✖ Query 1 ✖ Query ✖ Query 4 ✖ +

https://nfdi4culture.de/sparql

```
SELECT DISTINCT ?orgLabel ?nfdiLabel
WHERE {
 #?contribution nfdico:publisher ?organisation .
  ?organisation rdf:type nfdico:Organization .
  ?organisation rdfs:label ?orgLabel FILTER(LANG(?orgLabel)="de")
  ?organisation owl:sameAs ?wdorg .
  BIND(IRI(replace(STR(?wdorg),"https://www.wikidata.org/entity/","http://www.wikidata.org/entity/")) AS ?wdorganisation)
  SERVICE <https://query.wikidata.org/sparql> {
        ?nfdi wdt:P31 wd:Q98270496 ;
              wdt:P1416 ?wdorganisation .
        ?nfdi rdfs:label ?nfdiLabel FILTER (LANG(?nfdiLabel)="de") .
  }
} ORDER BY ?orgLabel

```

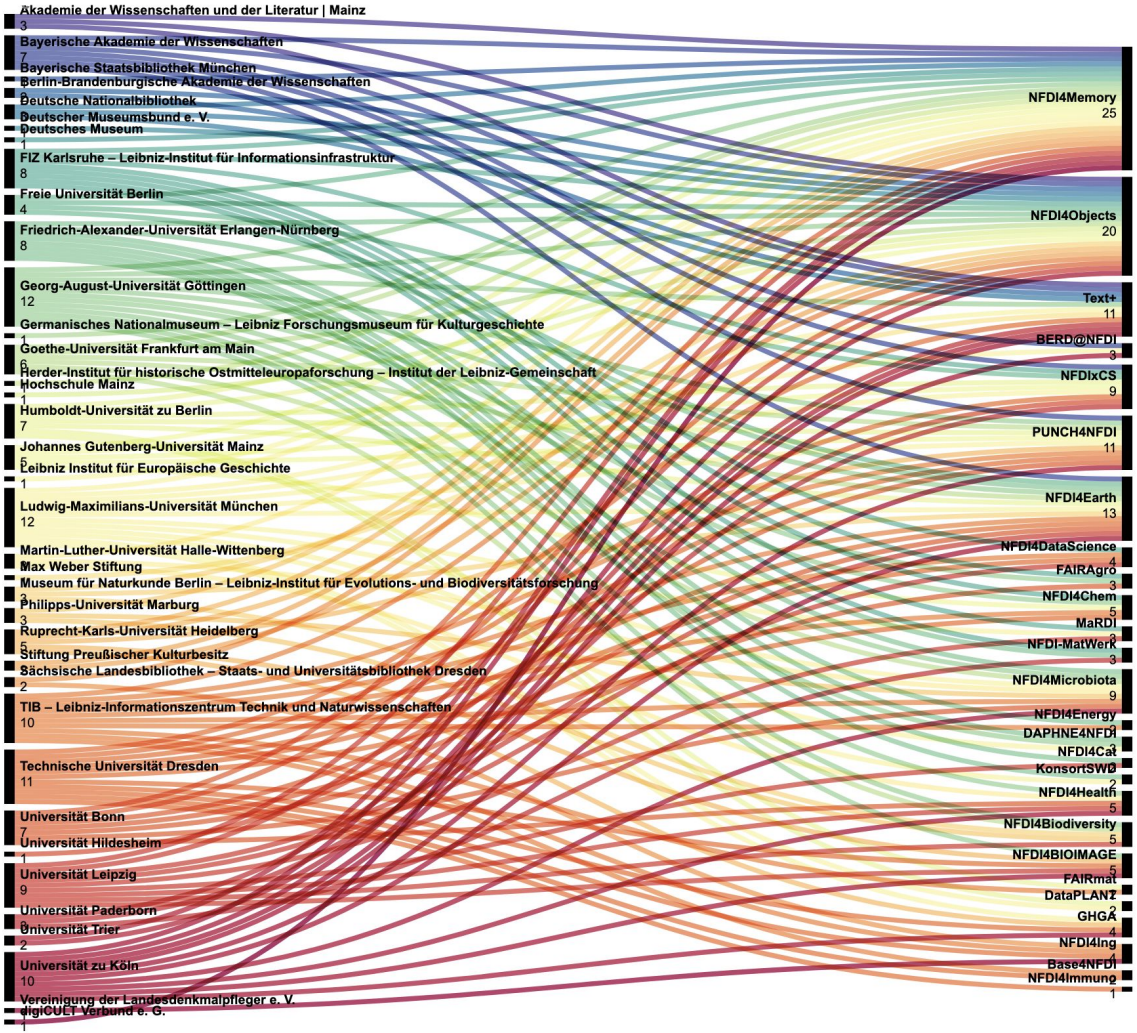
Table | Response | 213 results in 0.857 seconds | Simple view ☐ Ellipse ☑ | Filter query results | Page size: 50

	orgLabel	nfdiLabel
1	"Akademie der Wissenschaften und der Literatur | Mainz"@de	"NFDI4Memory"@de
2	"Akademie der Wissenschaften und der Literatur | Mainz"@de	"Text+"@de
3	"Akademie der Wissenschaften und der Literatur | Mainz"@de	"NFDI4Culture"@de
4	"Akademie der Wissenschaften und der Literatur | Mainz"@de	"NFDI4Objects"@de
5	"Arbeitskreis Digitale Kunstgeschichte"@de	"NFDI4Culture"@de
6	"Arbeitskreis Provenienzforschung e. V."@de	"NFDI4Memory"@de
7	"Bach-Archiv Leipzig"@de	"NFDI4Culture"@de
8	"Bayerische Akademie der Wissenschaften"@de	"NFDI4Culture"@de
9	"Bayerische Akademie der Wissenschaften"@de	"BERD@NFDI"@de
10	"Bayerische Akademie der Wissenschaften"@de	"NFDIxCS"@de
11	"Bayerische Akademie der Wissenschaften"@de	"NFDI4Earth"@de
12	"Bayerische Akademie der Wissenschaften"@de	"PUNCH4NFDI"@de
13	"Bayerische Akademie der Wissenschaften"@de	"NFDI4Memory"@de
14	"Bayerische Akademie der Wissenschaften"@de	"NFDI4Objects"@de
15	"Bayerische Akademie der Wissenschaften"@de	"Text+"@de
16	"Bayerische Staatsbibliothek München"@de	"NFDI4Memory"@de
17	"Bayerische Staatsbibliothek München"@de	"NFDI4Culture"@de

SPARQL Endpoint Data Exploration

1. List all publications of NFDI4Culture for the progress report aligned to FaBIO
2. *List all **other NFDI consortia** in which NFDI4Culture members are involved in **for the progress report** (via federation with Wikidata)*

SPARQL Query



SPARQL Endpoint Data Exploration

1. List all publications of NFDI4Culture for the progress report aligned to FaBIO
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SPARQL Query

2. Provision of information about research data

NFDIxxx Research Data Graphs

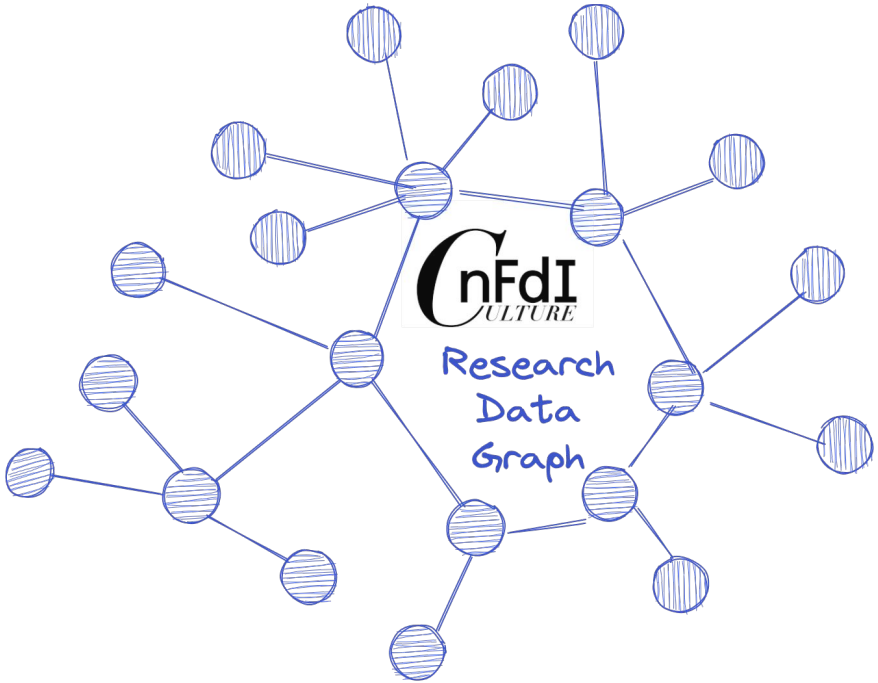
Content:

- **Metadata for NFDI consortium related research data** as e.g., from
  1. Fully fledged **LOD** research data
  2. **Standardized API-**based research data (non-LOD research data)
  3. **Web-based** “Legacy” research data
  4. **Wikibase**-based research data

Purpose:

- Metadata to enable **retrieval, exploration, federation** and **analysis** of NFDI research data resources
- **Connectivity** to external resources (NFDI and non-NFDI)

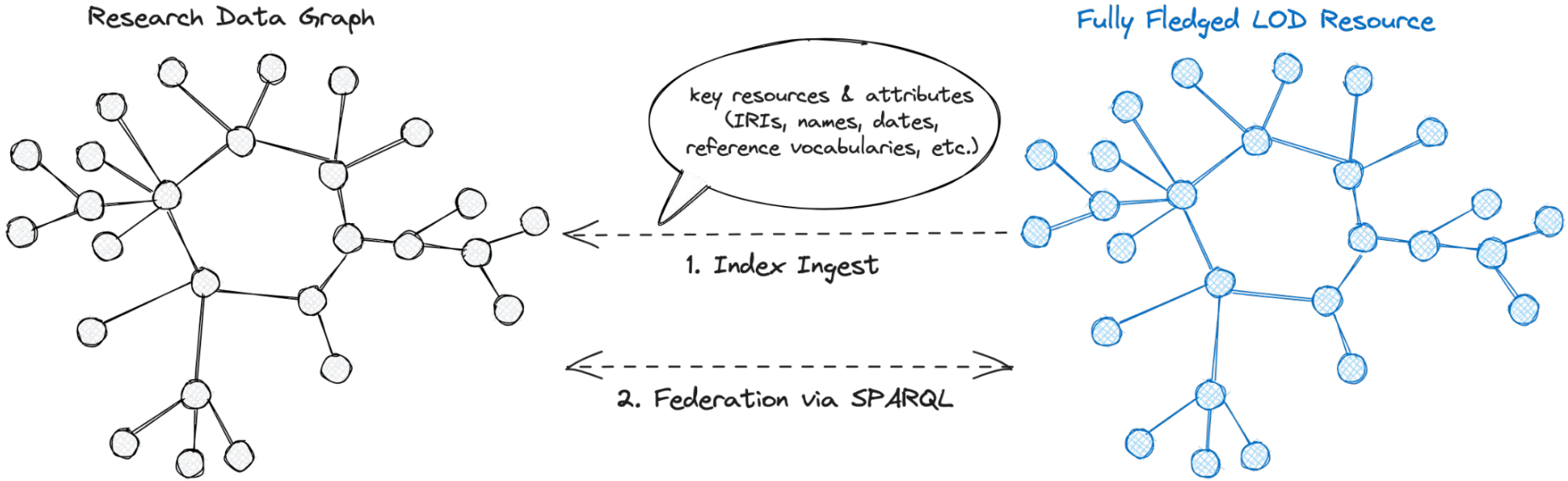
Example: NFDI4Culture Research Data KG



Content:

- **Metadata for NFDI4Culture content** as e.g., from
  1. Fully fledged **LOD** research data
  2. **OAI-PMH / LIDO / MARC21** API based research data
  3. **Web-based** “Legacy” research data
  4. **Wikibase**-based resources

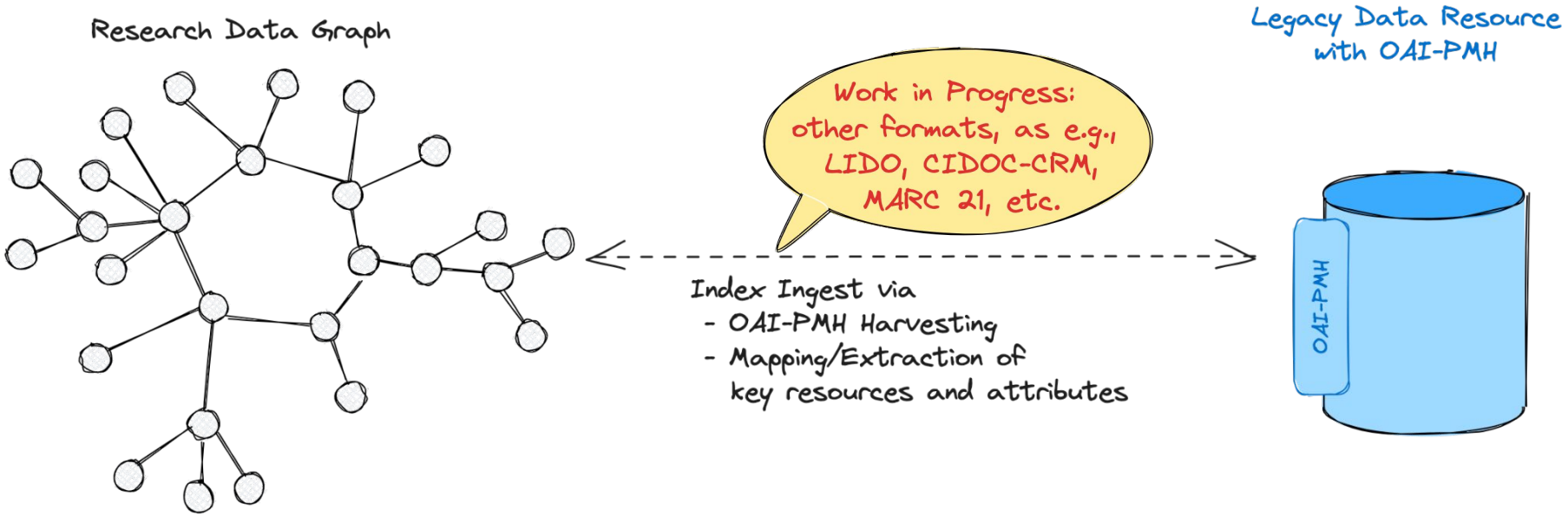
Content Variant 1: LOD via SPARQL Endpoint



serves as a
centralized semantic index
for **search** and **discovery**

provides
distributed semantic data resources

Content Variant 2: OAI-PMH (or other reference data formats)

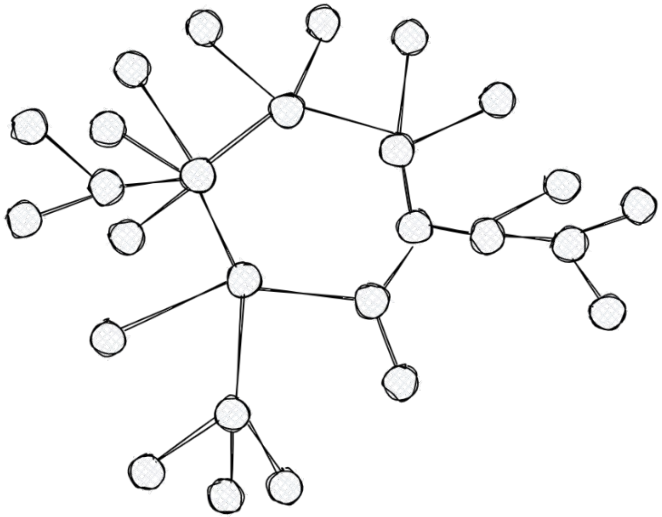


enables **search** and **discovery** via **cross connections** and **federation with (other) external knowledge**

No direct query federation possible

Content Variant 3: Structured Web Data

Research Data Graph

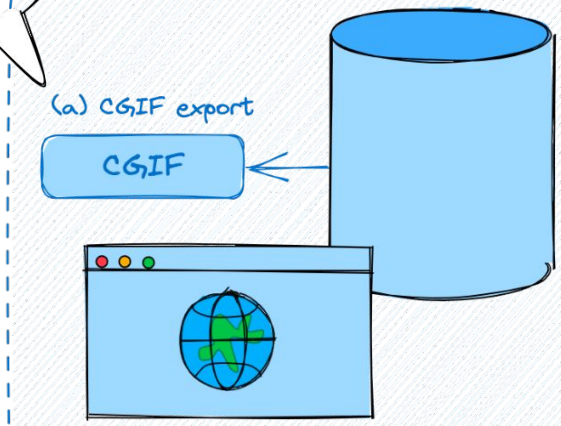


enables **search** and **discovery**
via **cross connections**
and **federation with (other)**
external knowledge

lightweight schema.org-based
data interchange format

Index Ingest via
a) CGIF export or
b) CGIF harvesting

Legacy Data Resource
with Entity-based
Web-Access



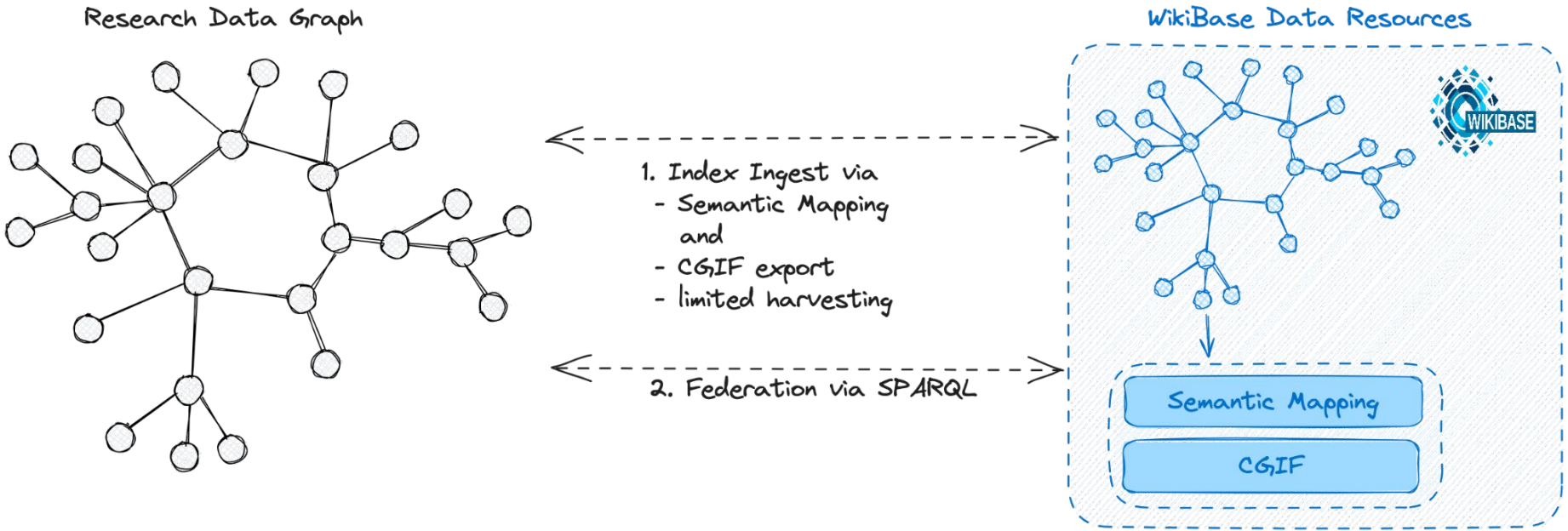
No direct query federation possible

Data Integration with CGIF

CGIF 1.0: https://nfdi4culture.de/go/E3712

- Lightweight interchange format based on **schema.org** for harvesting resources with **key attributes** (IRIs, names, dates, locations, terms)
- **No API required** - integration into the Research Data Graph KG just by **adding a bit of markup to a website**
- **Added benefit** of automatically making the website / data eligible for Google Dataset Search

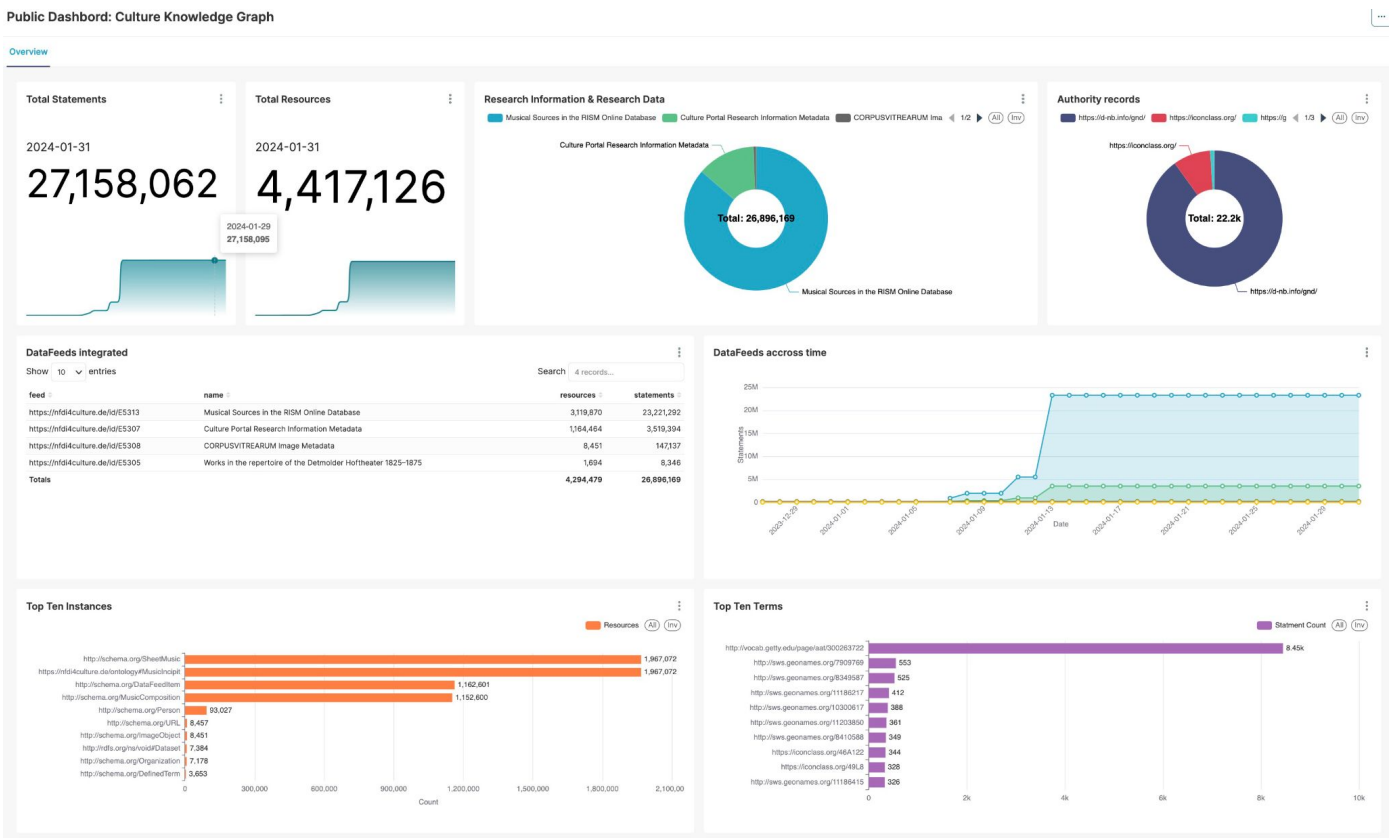
Content Variant 4: Wikibase KGs



serves as a
centralized semantic index
for **search** and **discovery**

provides
distributed semantic data resources

NFDI4Culture Research Data KG Dashboard



[NFDI4Culture Dashboard]

- Automated ETL environment for **data feed ingest**, **data synchronization**, and **status monitoring**
- RDF-based **Workflow Management System**

https://nfdi4culture.de/sparql

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX schema: <http://schema.org/>
PREFIX wdt: <http://www.wikidata.org/prop/direct/>
PREFIX wd: <http://www.wikidata.org/entity/>

SELECT DISTINCT ?s ?ic3 ?o1 ?o2 WHERE {
  SERVICE <https://query.wikidata.org/sparql> {
    wd:Q500242 wdt:P1257 ?ic . # Iconclass Code for Michelangelo's Creation of A
    BIND((SUBSTR(STR(?ic),STRLEN(STR(?ic))-6,4)) AS ?ic3)
  }
  ?s ?p ?o FILTER regex (STR(?o),?ic3,"i") .
  ?s schema:name ?o1 ;
     schema:contentLocation ?o2 .
} LIMIT 100
```

Table | Response | 52 results in 5.873 seconds | Simple view | Ellip

	s	ic3	o1	
1	<https://corpusvitrearum.de/id/F2347>	"71A\"^...	"Vertreibung aus dem Paradies (Detail)"@de	
2	<https://corpusvitrearum.de/id/F2068>	"71A\"^...	"Architekturprospekt mit den Standbildern A	
3	<https://corpusvitrearum.de/id/F20072>	"71A\"^...	"Trennung von Land und Wasser / Erschaffu	
4	<https://corpusvitrearum.de/id/F2324>	"71A\"^...	"Erschaffung der Gestirne (Detail)"@de	
5	<https://corpusvitrearum.de/id/F2784>	"71A\"^...	"Kain erschlägt Abel (Detail: Unterkörper)"@	
6	<https://corpusvitrearum.de/id/F4210>	"71A\"^...	"Die sechs Tage der Schöpfung (Detail: Fisc	
7	<https://corpusvitrearum.de/id/F2322>	"71A\"^...	"Trennung von Land und Wasser / Erschaffu	
8	<https://corpusvitrearum.de/id/F448>	"71A\"^...	"Adam und Eva"@de	
9	<https://corpusvitrearum.de/id/F4201>	"71A\"^...	"Genesiszyklus (Detail: Erschaffung der Mee	
10	<https://corpusvitrearum.de/id/F20158>	"71A\"^...	"Erschaffung der Engel (Detail)"@de	"Ulm, Deutschland"^^<http://www.w3.org/2001/X...
11	<https://corpusvitrearum.de/id/F2785>	"71A\"^...	"Kain erschlägt Abel (Detail: Oberkörper)"@de	"München, Deutschland"^^<http://www.w3.org/...
12	<https://corpusvitrearum.de/id/F4211>	"71A\"^...	"Die sechs Tage der Schöpfung (Detail: Erschaffung von Landtie...	"Marburg, Deutschland"^^<http://www.w3.org/...
13	<https://corpusvitrearum.de/id/F20069>	"71A\"^...	"Vertreibung aus dem Paradies"@de	"Ulm, Deutschland"^^<http://www.w3.org/2001/X...
14	<https://corpusvitrearum.de/id/F2341>	"71A\"^...	"Kain erschlägt Abel (Detail)"@de	"Ulm, Deutschland"^^<http://www.w3.org/2001/X...
15	<https://corpusvitrearum.de/id/F1762>	"71A\"^...	"Baum der Erkenntnis mit Schlange"@de	"Tübingen, Deutschland"^^<http://www.w3.org...
16	<https://corpusvitrearum.de/id/F1605>	"71A\"^...	"Sündenfall und Hl. Michael mit Mondsichelmadonna"@de	"Schwäbisch Hall, Deutschland"^^<http://ww...
17	<https://corpusvitrearum.de/id/F2344>	"71A\"^...	"Sündenfall (Detail)"@de	"Ulm, Deutschland"^^<http://www.w3.org/2001/X...

Trennung von Land und Wasser / Erschaffung der Pflanzen

Münster Unserer Lieben Frau, Ulm (um 1430/31) CVMA Band I,3

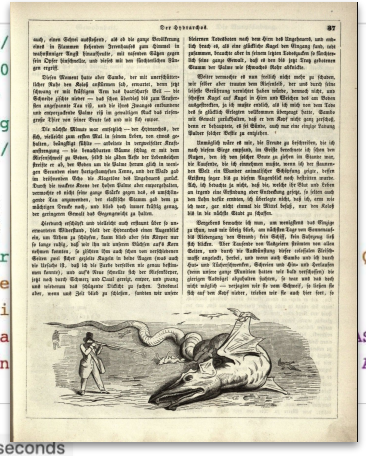
Foto: Andrea Gössel, Corpus Vitrearum Deutschland/Freiburg i. Br., CC BY-NC 4.0
Permalink: https://corpusvitrearum.de/id/F20072

SPARQL Endpoint Data Exploration

- ***Titles*** *and* ***Locations*** *of stained glass windows from* ***Corpus Vitrearum*** *that relate to* ***Michelangelo's "Creation of Adam"****?*
- via **Federation** of Research Data Graph with Wikidata
- using **Iconclass Codes**

SPARQL Query

Query



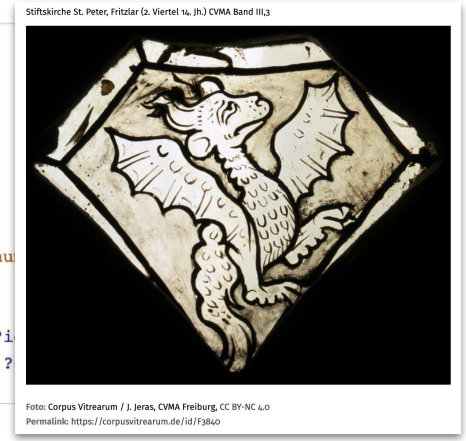
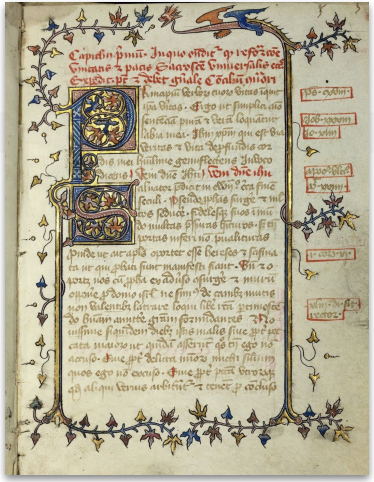


Table | Response | 666 results in 4.127 seconds



s	
1	<https://corp
2	<https://corp
3	<https://corp
4	<https://corp
5	<https://corp
6	<https://corp
7	<https://corp
8	<https://corpusvitrearum.de/id/F3949> "Maßwerkverglasung mit Drachenmotiven"@de
9	<https://corpusvitrearum.de/id/F3950> "Maßwerkverglasung mit Blütenrosetten und Drachen"@de
10	<https://corpusvitrearum.de/id/F4646> "Dreieckzwickel mit Mischwesen (Drachen?)"@de
11	<https://corpusvitrearum.de/id/F4647> "Dreieckzwickel mit Mischwesen (Drachen?)"@de
12	<https://corpusvitrearum.de/id/F5093> "Zwickel mit geflügeltem Mischwesen"@de
13	<https://corpusvitrearum.de/id/F5096> "Zwickel mit geflügeltem Mischwesen"@de

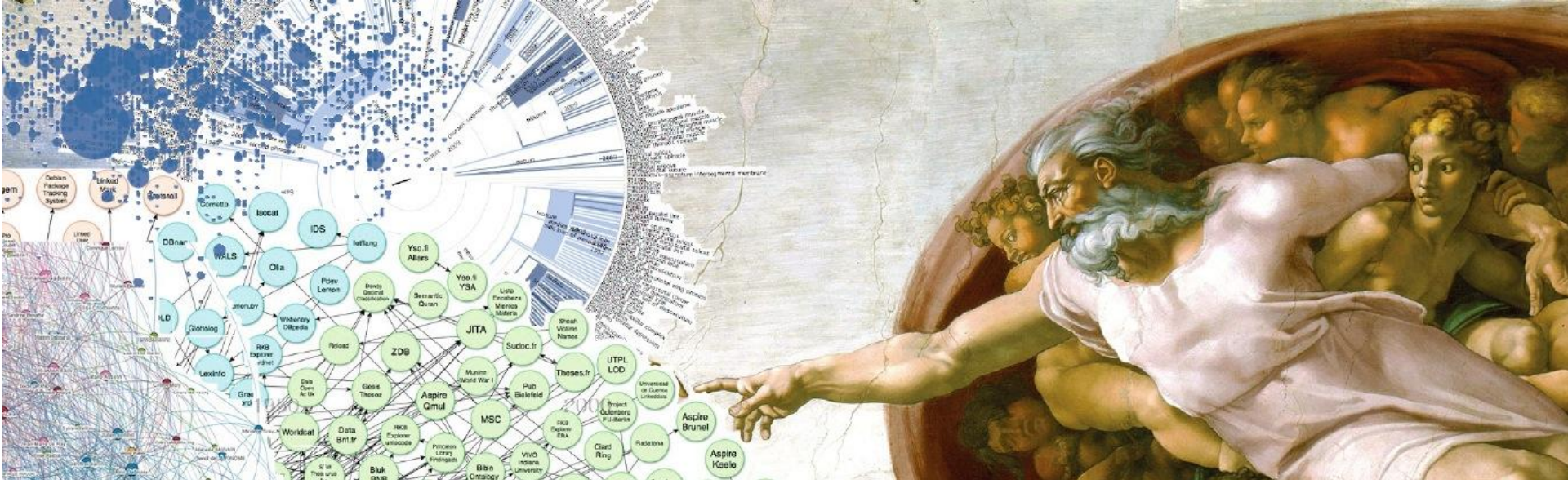
SPARQL Endpoint Data Exploration

- *Are there "**Dragons**" among the **NFDI4Culture research data resources**?*
- via **Federation** of Research Data Graph with Wikidata
- using **Iconclass Codes** and **GND identifiers**

SPARQL Query

Summary

- Knowledge Graph based Research Data Management
- Modular NFDIcore ontologies to represent NFDI consortia and their research data
- Knowledge Graph-based Information Portal for interactive data curation including an automated ETL environment
- Research data integration also for heterogeneous (legacy) repository technologies
- Centralized semantic index to enable semantic and exploratory search and discovery



Knowledge Graph-based RDM Solutions

NFDI4Culture, NFDI-MatWerk, NFDI4DataScience und mehr ...

Prof. Dr. Harald Sack
NFDI4Memory Ontologies Workshop
München, 30.01.2024

email: harald.sack@fiz-karlsruhe.de
Fediverse: @lysander07@sigmoid.social

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Prof. Dr. Harald Sack

Course has not yet started

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Despite the fact that it affects our lives on a daily basis, most of us are unfamiliar with the concept of a knowledge graph. When we ask Alexa about tomorrow's weather or use Google to look up the latest news on climate change, knowledge graphs serve as the foundation of today's cutting-edge information systems. In addition, knowledge graphs have the potential to elucidate, assess, and substantiate information produced by Deep Learning models, such as Chat-GPT and other large language models. Knowledge graphs have a wide range of applications, including improving search results, answering questions, providing recommendations, and developing explainable AI systems. In essence, the purpose of this course is to provide a comprehensive overview of knowledge graphs, their underlying technologies, and their significance in today's digital world.

October 11, 2023 - November 21, 2023

Language: English

Big Data and AI, Expert

Enroll me for this course

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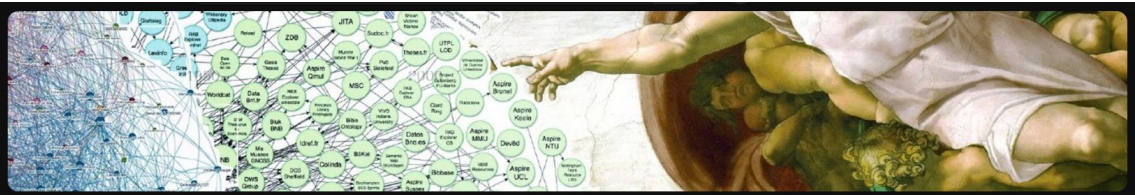

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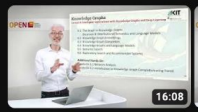

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Paper & Panel Submission Deadline: **March 7, 2024**

https://semdh.github.io/

Bibliography

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