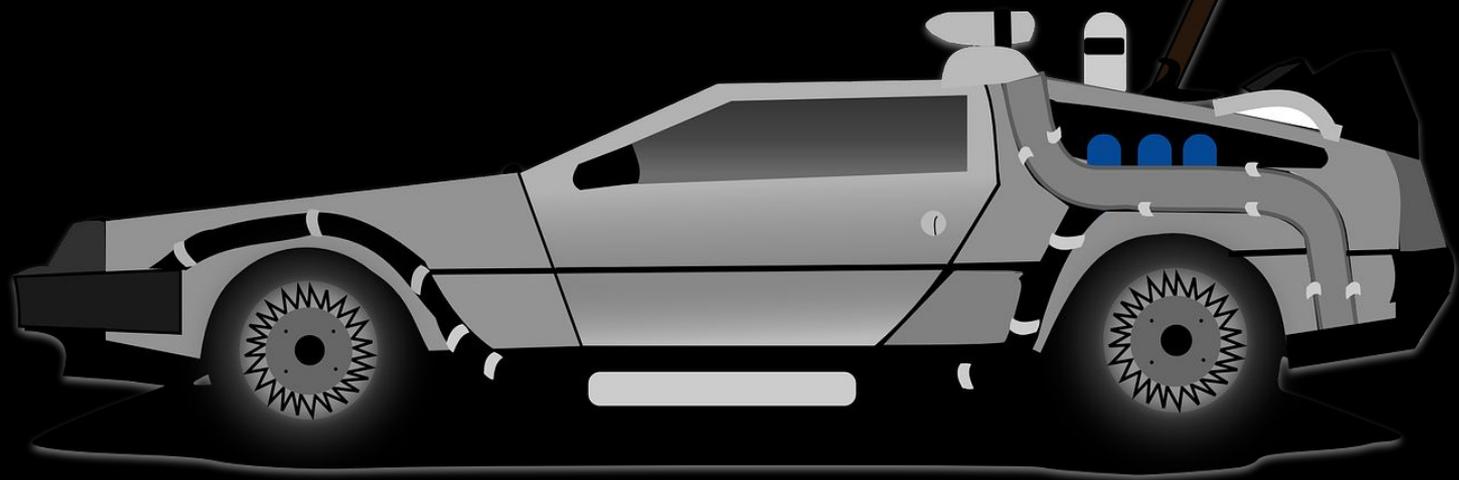


**“Die Welt ist klein und man trifft sich immer zweimal...”**



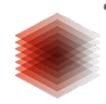
oder  
**Forschungsdateninfrastrukturen und die Renaissance der Normdaten**

Prof. Dr. Harald Sack  
GNDCon 2.0  
Frankfurt, 7. Juni 2021



2011





# 2011



**Digitalisierung** ▶ visuelle Analyse ▶ semantische Analyse ▶ semantische Annotation



[4]

Digitalisierung ▶ **visuelle Analyse** ▶ semantische Analyse ▶ semantische Annotation

01 Einführung, Kommunikationsmedium Internet Dr. Harald Sack  
Rechnernetze und Internettechnologie

To bookmark current scene,  
right mouse click [here](#).

Tagging | Lecture Series | Slides | Discussions

my all Tags current all Video(s)

1500bc ablauf agamemnon  
ägypten aischylos alphabet  
alteuropäisch alteuropäische  
altsumerisch amalia amman analical

**anekdote**

anna  
annaamalia antike archivierung  
artefakte österreich attischer augustus  
ausprache austausch autoren bücher  
babbage babylon bagdad balkan  
bandbreite bandkeramik bankkeramik  
bedeutung beförderung begrenzung belgien  
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new tag

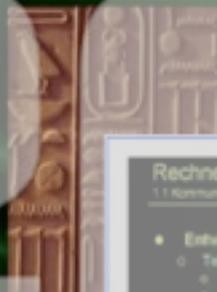
## Rechnernetze und Internettechnologien

1.1 Kommunikationsmedien - von der Höhlenmalerei zu HDTV

### Entwicklung der Schrift (3/5)



Babylonische Keilschrift  
ab ca. 3500 v. Chr.



Ägyptische  
ab ca. 3000 v. Chr.



## Rechnernetze und Internettechnologien

1.1 Kommunikationsmedien - von der Höhlenmalerei zu HDTV

### Entwicklung der Telekommunikation (1/5)

- Telefon und Individualkommunikation
  - 1. Jhd. v. Chr. - Katakomben-Fibel, Selbstverleumdung
  - 10. Jhd. - Isidors Notizen, Wörterbücher
  - 1875, Philip Reis, erster Telephonversuch
  - 1876, A.G. Bell und G. Gray, erstes Telefon
  - 1885, Gründung der AT&T
  - 1898, A.S. Bruggen, Selbstverleumdung
  - 1902, Isidors Notizen, Wörterbücher



Corpuslinguistik  
Statistische Lernverfahren  
Explizite Wissensrepräsentationen

**unstrukturierte Daten**  
Audio, Video, Bilder & Texte

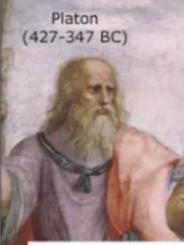


Digitalisierung ▶ visuelle Analyse ▶ **semantische Analyse** ▶ **semantische Annotation**

Search for people, places, topics ...

Search

# 05 Semantic Web Technologien - Ontologies



Platon  
(427-347 BC)

## Ontology in Classical Greek Philosophy

Platons Cave Parabel

- from Platon's 'Politeia', 7. Book, ca. 370 BC









32:04 | 01:30:18

SERIES

ANNOTATIONS

TRANSCRIPT

Search ...

Speech

Text

Image

Beam (structure)

Social class

Platonic solid

Series (mathematics)

Quantum state

SOKRATES <Bibliotheksinformationssystem>

ACID

Set (mathematics)

Term (mathematics)

Category of being

Position

Bioinformatik

Systems <München>

Predicate (grammar)

Graph minor

Abbildung <Physik>

MUISE <Lernprogramm>

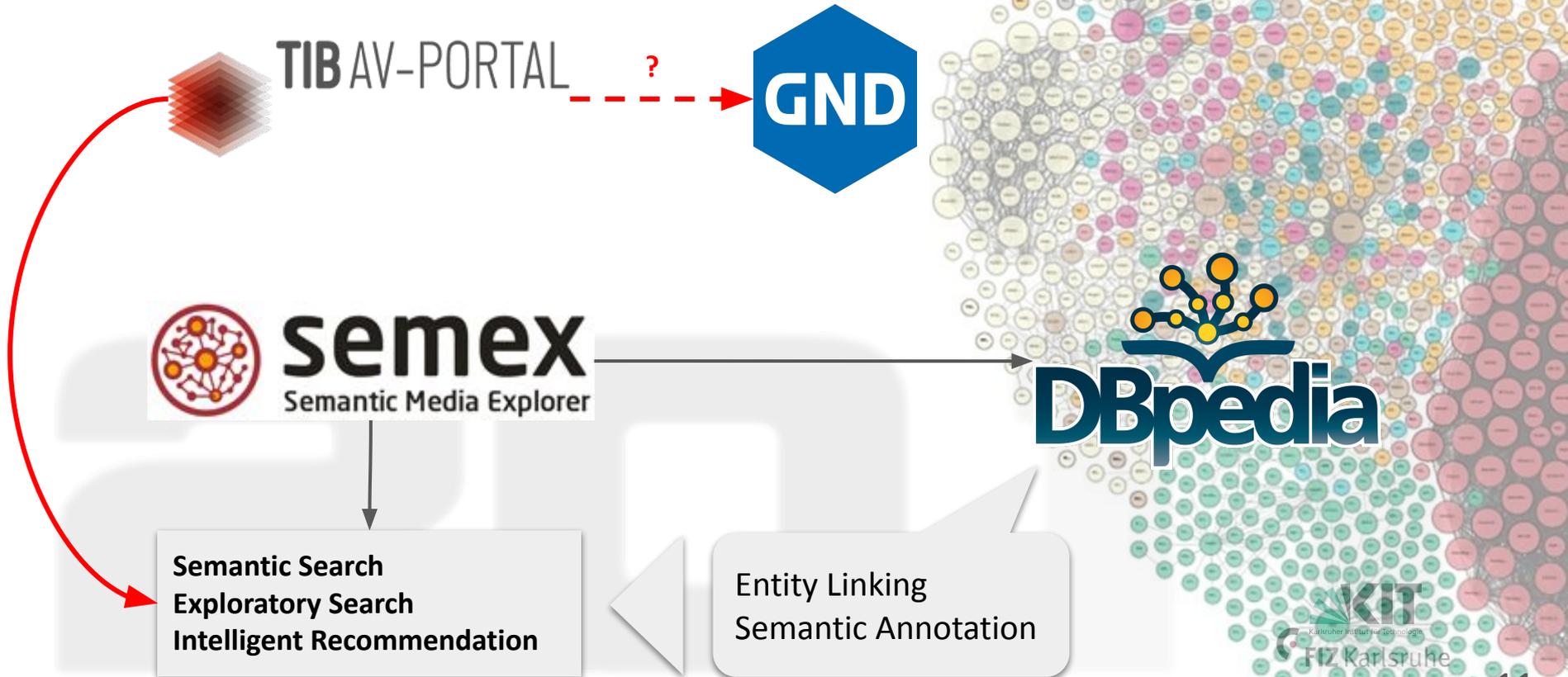
Object (grammar)

Curve fitting

## Innovative Informationssysteme

- verbessertes Retrieval
- Semantische Suche
- Explorative Suche
- Ähnlichkeitsbasierte Suche
- Intelligente Empfehlungen

# GND und Semantic Web?



# Problem 1: Ambiguität und (fehlender) Kontext

GND	
Link zu diesem Datensatz	<a href="http://d-nb.info/gnd/4190617-2">http://d-nb.info/gnd/4190617-2</a>
Sachbegriff	Zeitreise ←
Quelle	Spektrum Lex. Physik
Erläuterungen	Verwendungshinweis: Ohne HZ Motiv
Synonyme	Zeitmaschine Zeitreise <Motiv>
Oberbegriffe	Beispiel für: Motiv
Systematik	12.4 Literarische Motive, Stoffe, Gestalten ; 13.1c Sachliche Motive in der Kunst
Typ	Zweifelsfall (szz)
Andere Normdaten	LCSH: Time travel RAMEAU: Voyages dans le temps
Thema in	1290 Publikationen  1. [Magic tree house] Das magische Baumhaus Leipzig : Deutsche Nationalbibliothek, 2021 2. Die Rückkehr der Templer Leipzig : Deutsche Nationalbibliothek, 2021 3. ...
Maschinell verknüpft mit	151 Publikationen  1. Außendienst Weber-Lortsch, Christian-Ludwig. - Wiesbaden : Springer Fachmedien Wiesbaden, 2021, 1. Auflage 2021 2. Bernár auf Zeitreise Stachel, Wolf. - Berlin : epubli, 2021, 2. Auflage 3. ...

GND

## Alle Normdaten

- Personen (1)
- Werke (12)
- Sachbegriffe (1)
- Organisationen (6)
- Veranstaltungen (20)
- Musiklabel (1)

# Problem 2: Vollständigkeit und Updatezyklen

	
<b>Link zu diesem Datensatz</b>	<a href="http://d-nb.info/gnd/4190617-2">http://d-nb.info/gnd/4190617-2</a>
<b>Sachbegriff</b>	Zeitreise
<b>Quelle</b>	Spektrum Lex. Physik
<b>Erläuterungen</b>	Verwendungshinweis: Ohne HZ Motiv
<b>Synonyme</b>	Zeitmaschine Zeitreise <Motiv>
<b>Oberbegriffe</b>	Beispiel für: <a href="#">Motiv</a>
<b>Systematik</b>	12.4 Literarische Motive, Stoffe, Gestalten ; 13.1c Sachliche Motive
<b>Typ</b>	Zweifelsfall (szz)
<b>Andere Normdaten</b>	LCSH: <a href="#">Time travel</a> RAMEAU: <a href="#">Voyages dans le temps</a>
<b>Thema in</b>	1290 Publikationen <ol style="list-style-type: none"><li><i>[Magic tree house]</i> <i>Das magische Baumhaus</i> Leipzig : Deutsche Nationalbibliothek, 2021</li><li><i>Die Rückkehr der Templer</i> Leipzig : Deutsche Nationalbibliothek, 2021</li><li>...</li></ol>
<b>Maschinell verknüpft mit</b>	151 Publikationen <ol style="list-style-type: none"><li><i>Außendienst</i> Weber-Lortsch, Christian-Ludwig. - Wiesbaden : Springer, 2021 1. Auflage 2021</li><li><i>Bernár auf Zeitreise</i> Stachel, Wolf. - Berlin : epubli, 2021, 2. Auflage</li><li>...</li></ol>



## Zeitreise (Begriffsklärung)

**Zeitreise** steht für:

- **Zeitreise**, Bewegung in der Zeit
- **Zeitreise (Geodaten)**, Bewegung in der Zeit als Darstellung von Geodaten
- Leben von Schauspielern in einer der Vergangenheit nachempfundenen Umgebung, siehe [Living History](#)
- Fernsehsendung auf [N24](#)
- **Zeitreise (Unheilig-Album)**, Musikalbum der deutschen Rockband Unheilig
- **Zeitreise (Schiller-Album)**, Musikalbum des deutschen Musikprojekts Schiller
- **Zeitreise Live**, Musikalbum des deutschen Musikprojekts Schiller
- **Terra X: Zeitreise**, dreiteilige Dokumentation der [Terra X](#) Reihe von 2014

**Siehe auch:**

- [Zeitreihe](#)



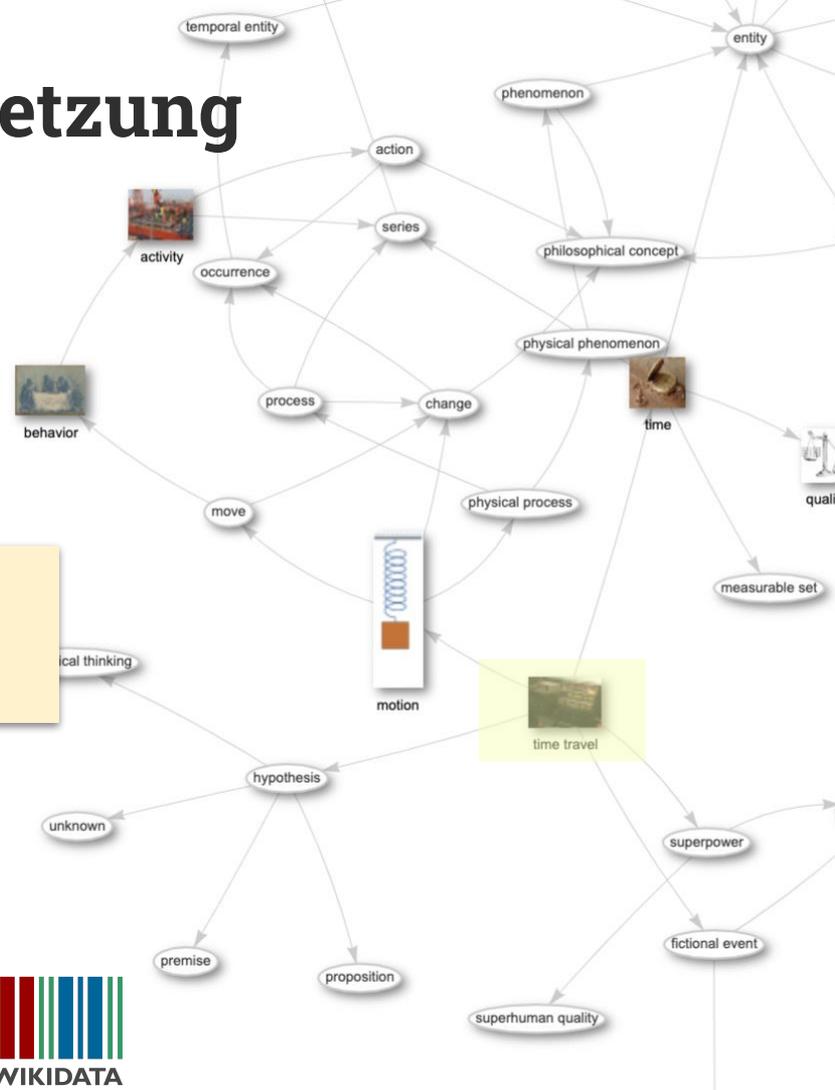
**WIKIPEDIA**  
Die freie Enzyklopädie

# Problem 3: fehlende Quervernetzung

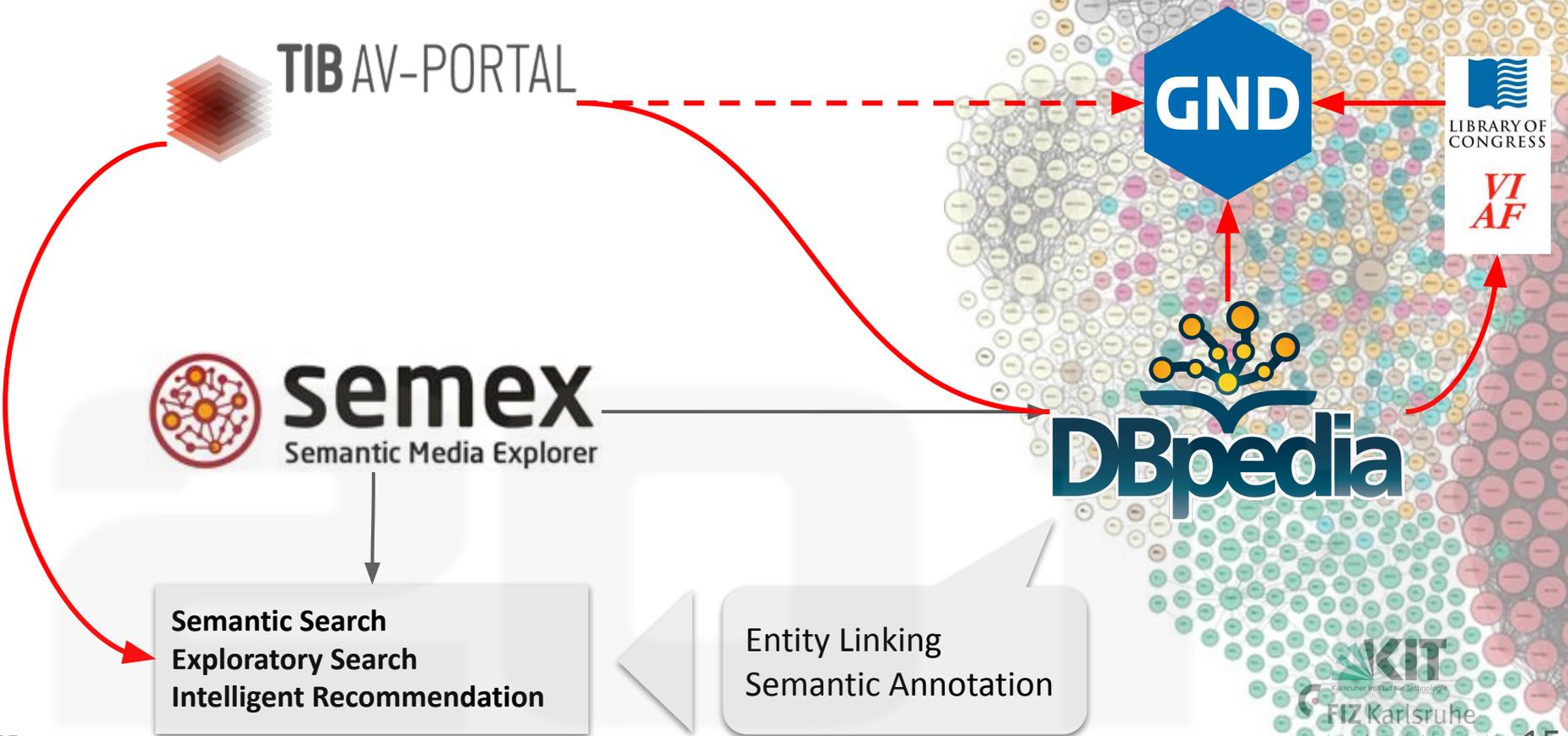
GND	
<b>Link zu diesem Datensatz</b>	<a href="http://d-nb.info/gnd/4190617-2">http://d-nb.info/gnd/4190617-2</a>
<b>Sachbegriff</b>	Zeitreise
<b>Quelle</b>	Spektrum Lex. Physik
<b>Erläuterungen</b>	Verwendungshinweis: Ohne HZ Motiv
<b>Synonyme</b>	Zeitmaschine Zeitreise <Motiv>
<b>Oberbegriffe</b>	Beispiel für: Motiv
<b>Systematik</b>	12.4 Literarische Motive, Stoffe, Gestalten ; 13.1c Sachliche Motive in der Kunst
<b>Typ</b>	Zweifelsfall (szz)
<b>Andere Normdaten</b>	LCSH: Time travel RAMEAU: Voyages dans le temps
<b>Thema in</b>	1290 Publikationen <ol style="list-style-type: none"> <li>[<i>Magic tree house</i>] <i>Das magische Baumhaus</i> Leipzig : Deutsche Nationalbibliothek, 2011</li> <li><i>Die Rückkehr der Templer</i> Leipzig : Deutsche Nationalbibliothek, 2021</li> <li>...</li> </ol>
<b>Maschinell verknüpft mit</b>	151 Publikationen <ol style="list-style-type: none"> <li><i>Außendienst</i> Weber-Lortsch, Christian-Ludwig. - Wiesbaden : Springer Fachmedien Wiesbaden, 1. Auflage 2021</li> <li><i>Bernár auf Zeitreise</i> Stachel, Wolf. - Berlin : epubli, 2021, 2. Auflage</li> <li>...</li> </ol>

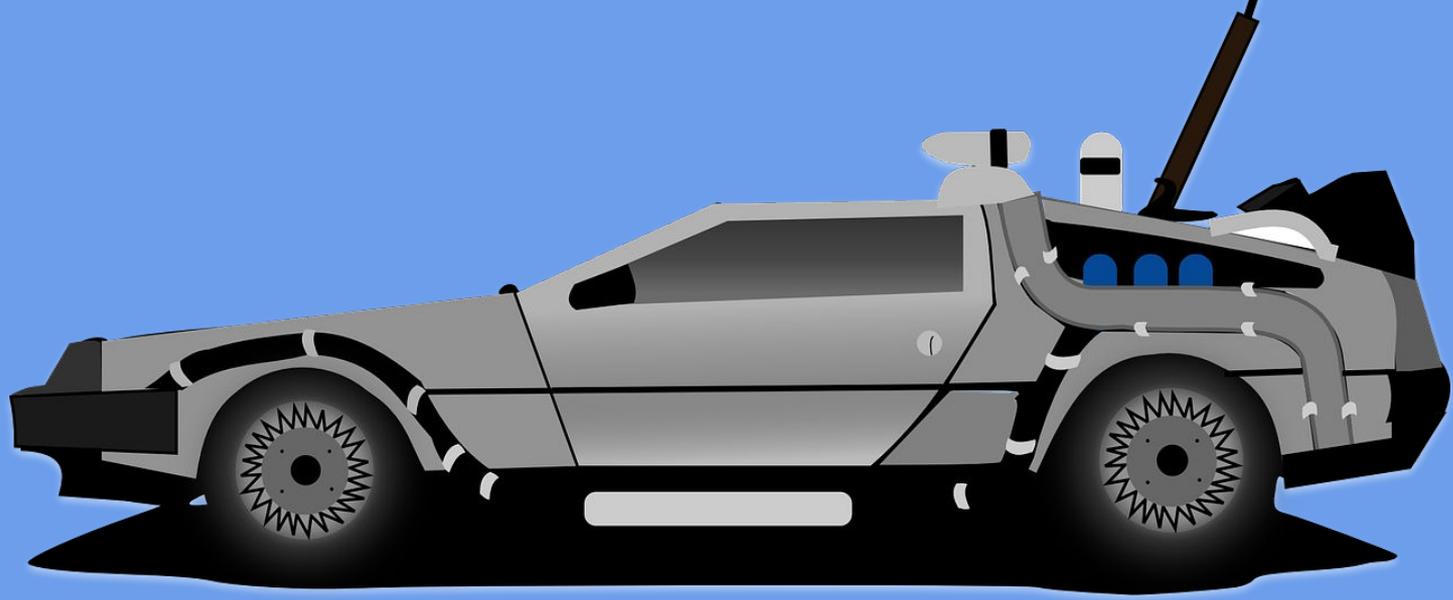


- Einfache Taxonomie
- Systematik als Kategoriensystem



# Auf Umwegen ins Semantic Web





2021



Geisteswissenschaften

Naturwissenschaften

Lebenswissenschaften

Sozialwissenschaften

Ingenieurwissenschaften

# Forschungsdaten



# Forschungs- datensilos

- Forschungsdaten abgeschlossen in **lokalen Datensilos**
- Zugriff nur via **proprietäre APIs**
- Ohne **spezielles Vorwissen** können Forschungsdaten kaum gefunden werden
- **Quervernetzung** zwischen Datenrepositorien **nahezu unmöglich**
- **FAIR Prinzipien** sind oft nur **unzureichend** umsetzbar

The background of the slide is a complex network of interconnected nodes and lines, overlaid on a faint world map. The nodes are represented by circles of varying sizes, some solid and some hollow, connected by thin lines. A prominent blue arrow curves across the upper right portion of the network. The overall color palette is dominated by shades of blue and grey.

# vernetzte Forschungsdaten



# Beispiel 1:

-21

-21°  
24.000

**-21°**  
**24.000**  
**Smolensk**

**-21°**  
**24.000**  
**Smolensk**

**14. November 1812**

	A	B	C	D	E	F	G	H	I
1	24	55	37.6	0	18	Oct	24	54.9	340000
2	25.3	54.7	36	0	24	Oct	24.5	55	340000
3	26.4	54.4	33.2	-9	9	Nov	25.5	54.5	340000
4	26.8	54.3	32	-21	14	Nov	26	54.7	320000
5	27.6	53.9	28.5	-20	28	Nov	28	54.9	280000
6	28.5	54.3	27.2	-24	1	Dec	28.5	55	240000
7	28.7	55.5	26.7	-20	6	Dec	29	55.1	210000
8	29.2	54.4	25.3	-25	7	Dec	30	55.2	180000
9	30.2	55.3	30.3				34.3	55.2	55000
10	30.4	54.5	32				33.3	54.8	37000
11	30.4	53.9	32				32	54.6	24000
12	32	54.8	34.4				30.4	54.4	20000
13	33.2	54.9	35.5				29.2	54.4	20000
14	34.3	55.2	36				28.5	54.3	20000
15	34.4	55.5	37.6				28.3	54.4	20000
16	36	55.5	37.5				24	55.1	60000
17	37.6	55.8	37				24.5	55.2	40000
18	36.6	55.3	36				25.5	54.7	20000
19	36.5	55	35.4				26.6	55.7	40000

**-21°**

**24.000**

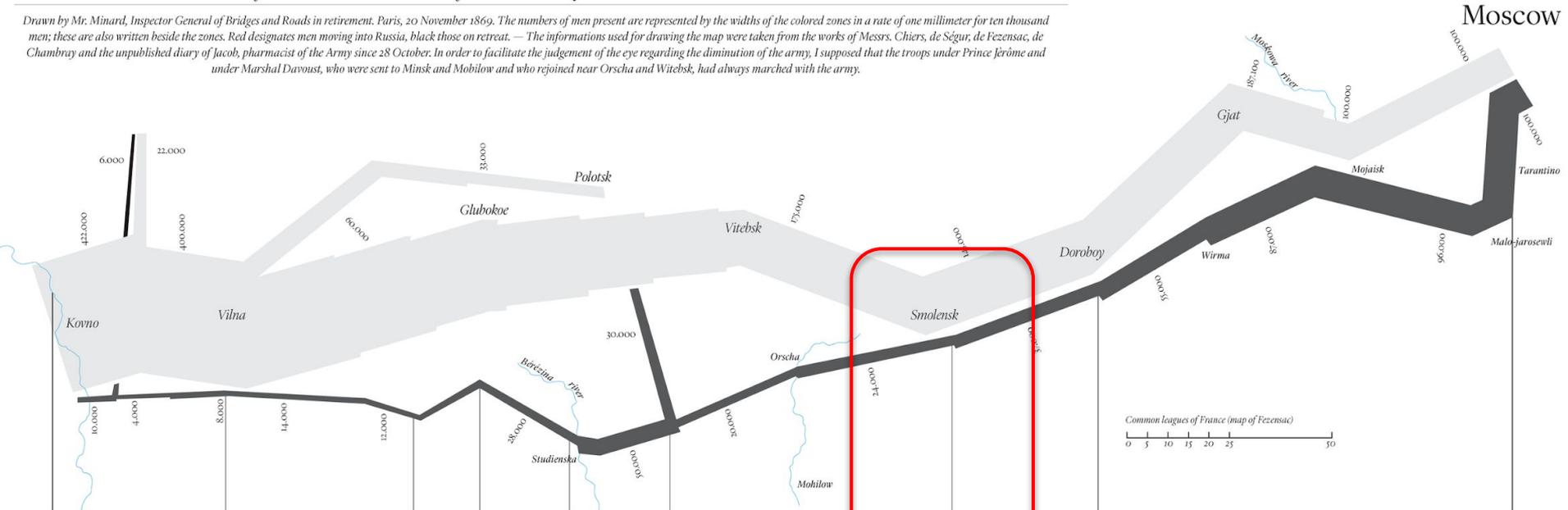
**Smolensk**

**14. November 1812**

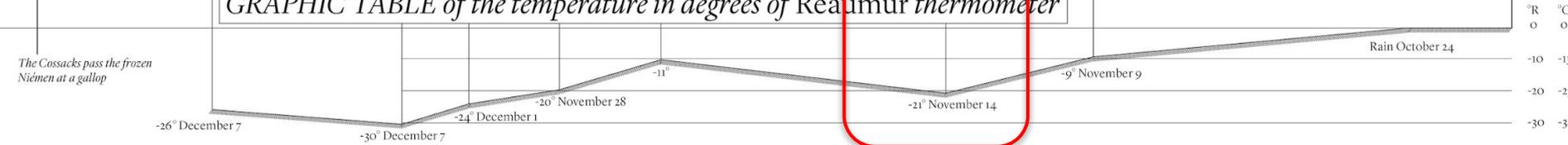


# FIGURATIVE MAP of the successive losses in men of the French Army in the RUSSIAN CAMPAIGN OF 1812-1813

Drawn by Mr. Minard, Inspector General of Bridges and Roads in retirement, Paris, 20 November 1869. The numbers of men present are represented by the widths of the colored zones in a rate of one millimeter for ten thousand men; these are also written beside the zones. Red designates men moving into Russia, black those on retreat. — The informations used for drawing the map were taken from the works of Messrs. Chiers, de Ségur, de Fezensac, de Chambray and the unpublished diary of Jacob, pharmacist of the Army since 28 October. In order to facilitate the judgement of the eye regarding the diminution of the army, I supposed that the troops under Prince Jérôme and under Marshal Davoust, who were sent to Minsk and Mohilow and who rejoined near Orscha and Witebsk, had always marched with the army.



## GRAPHIC TABLE of the temperature in degrees of Réaumur thermometer



Infographics by **Charles Minard** (1781-1870) from data of Napoleon's Russian Campaign 1812/13



# Beispiel 2:

# 14

14 m

— 14 m —

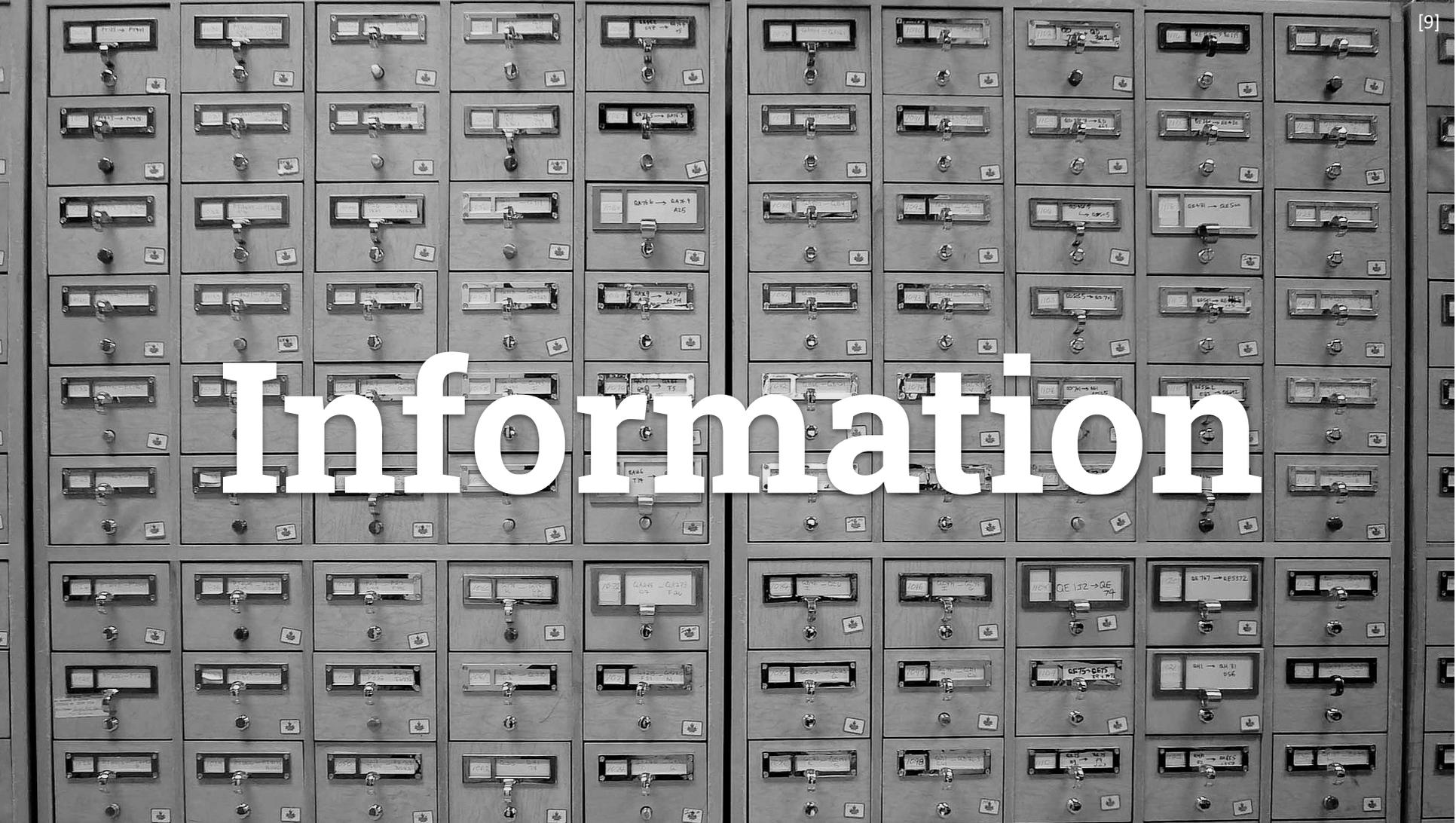


14 m

# Daten



# Information







**„People can't share knowledge  
if they don't speak a common language“**

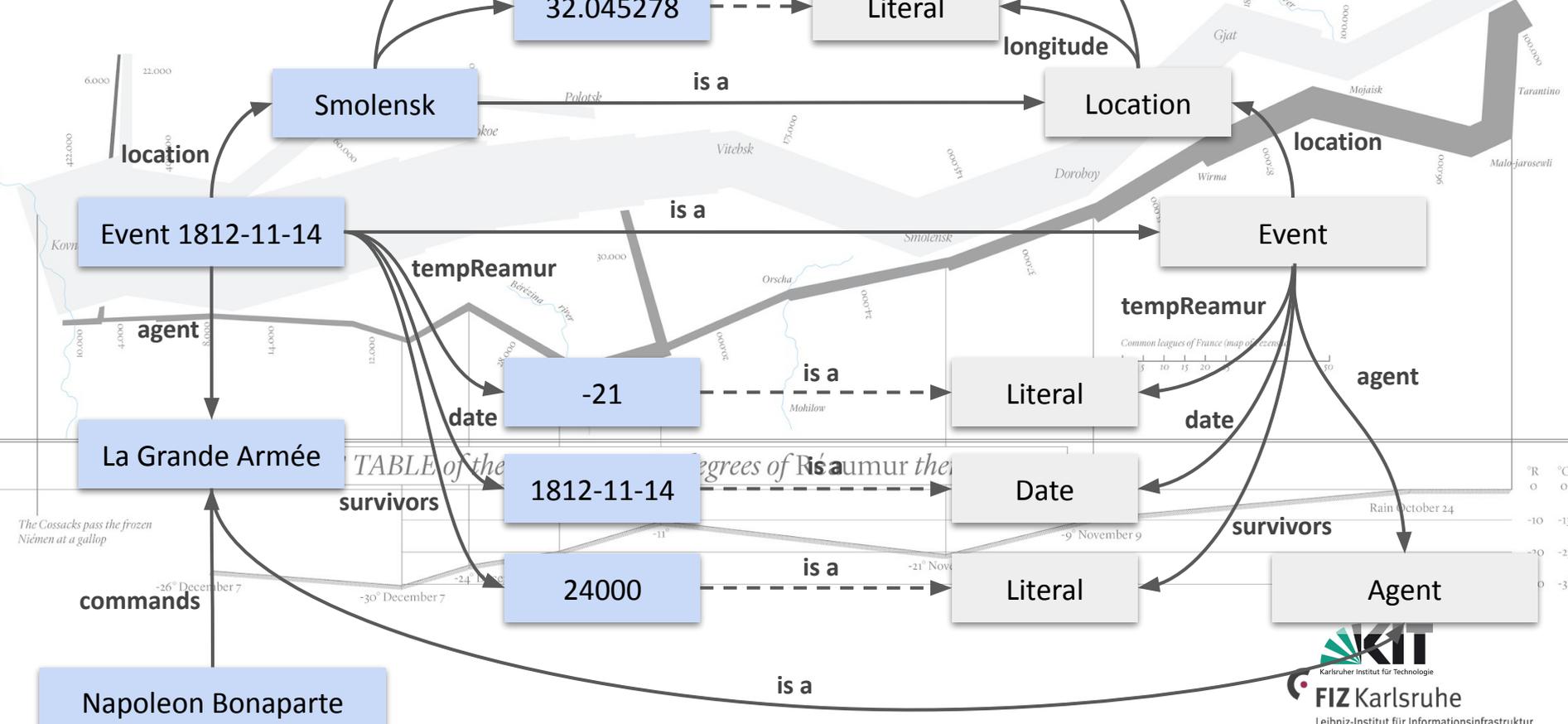
*Thomas Davenport (1997)*

## ...eine gemeinsame Sprache sprechen:

- Gemeinsame Symbole und Konzepte (**Syntax**)
- Übereinkunft über deren Bedeutung (**Semantik**)
- Klassifikation von Konzepten (**Taxonomien**)
- Assoziationen und Relationen zwischen Konzepten (**Thesauri**)
- Regeln darüber, welche Relationen erlaubt sind und Sinn machen (**Ontologien**)

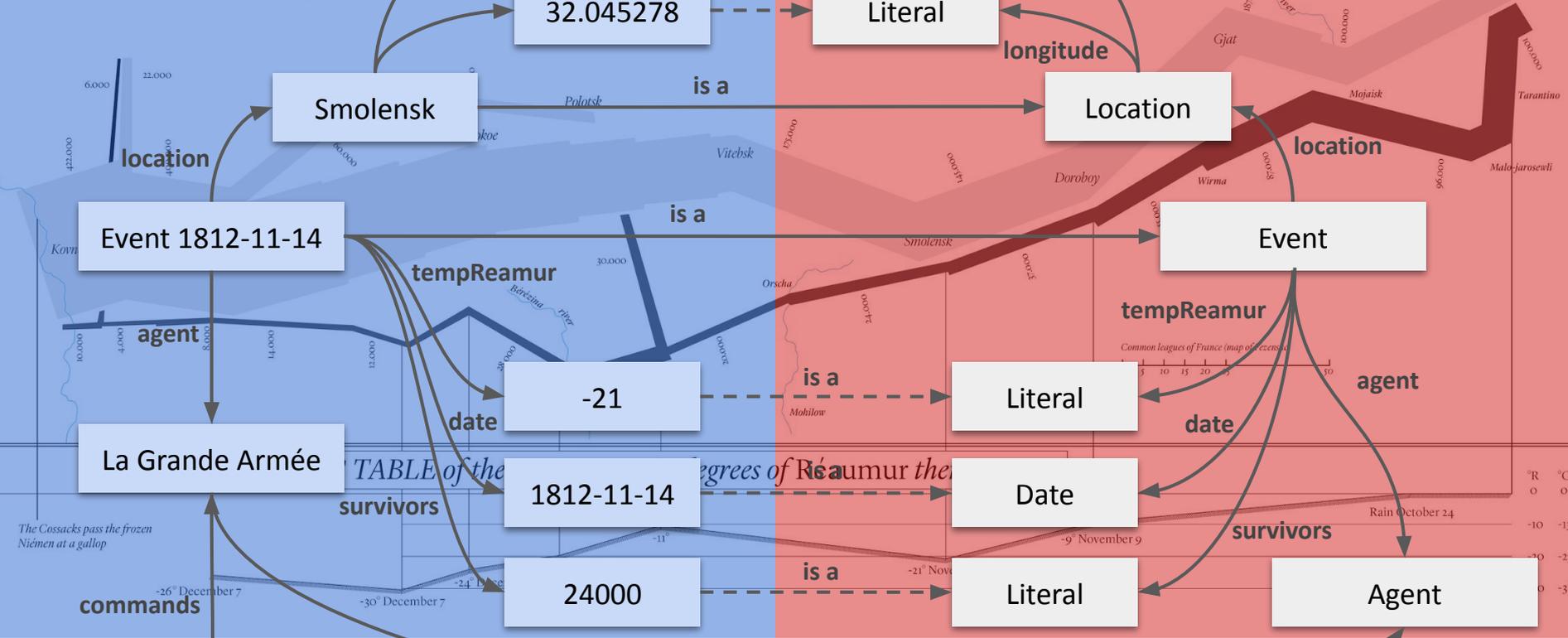
# FIGURATIVE MAP of the successive losses in men of the E...

Drawn by Mr. Minard, Inspector General of Bridges and Roads in retirement. Paris, 20 November 1869. The men; these are also written beside the zones. Red designates men moving into Russia, black those on retreat. — The informations used for drawing the map were taken from the works of Messrs. Chiers, de Ségur, de Feneznac, de Chambray and the unpublished diary of Jacob, pharmacist of the Army since 28 October. In order to facilitate the indentment of the map regarding the diminution of the army, I have always is a



# FIGURATIVE MAP of the successive losses in men of the Emperor's Army

Drawn by Mr. Minard, Inspector General of Bridges and Roads in retirement, Paris, 20 November 1869. The numbers written beside the zones indicate the number of men remaining at each stage. Red designates men moving into Russia, black those on retreat. — The informations used for drawing the map were taken from the works of Messrs. Chiers, de Ségur, de Pezencas, de Chambray and the unpublished diary of Jacob, pharmacist of the Army since 28 October. In order to facilitate the comparison of the losses, the distances are always marked with the common leagues of France (map of Pezencas).



54.782778  
32.045278

Literal  
Literal

1913  
latitude  
longitude

Smolensk

Location

Event 1812-11-14

Event

La Grande Armée

Literal

-21

date

1812-11-14

Date

24000

Literal

Agent

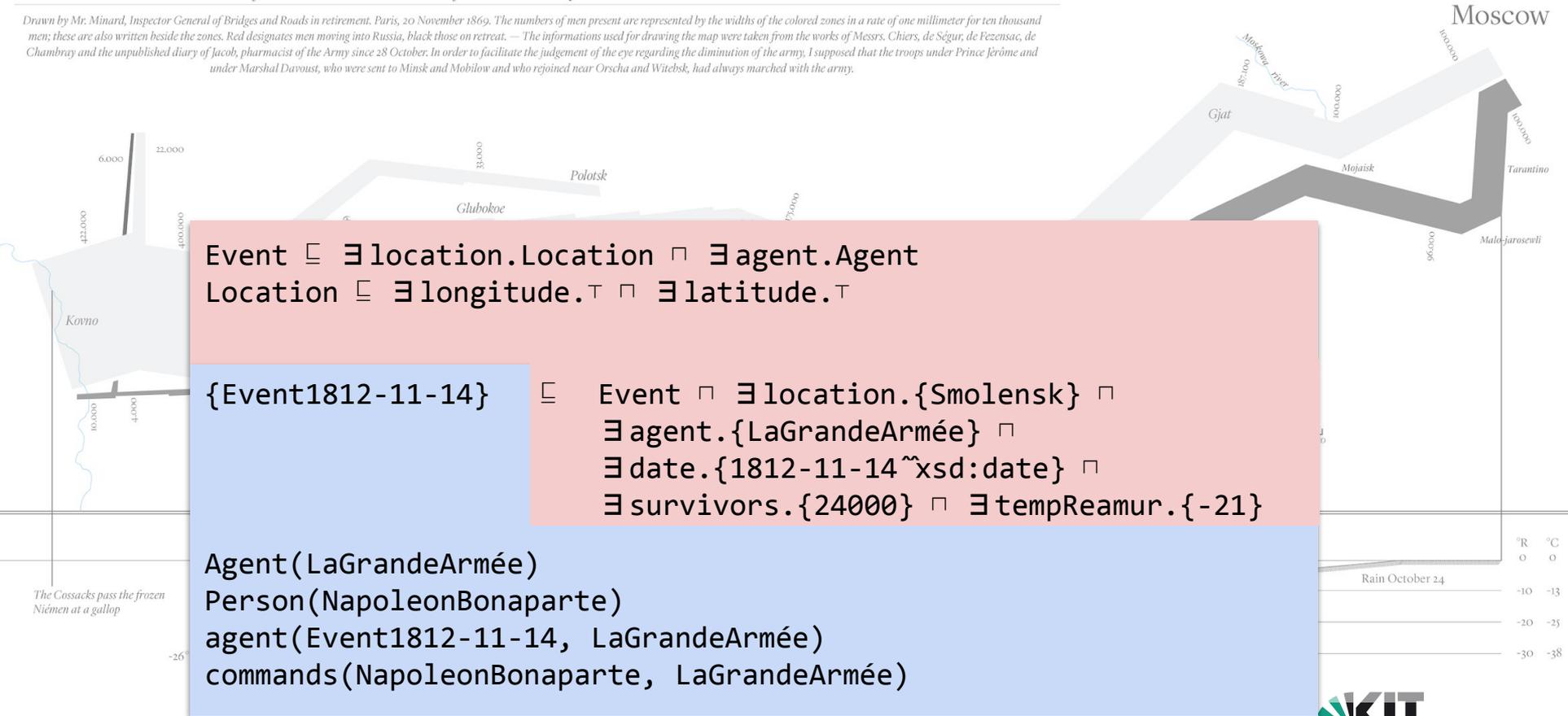
Napoleon Bonaparte

Assertionales Wissen

Terminologisches Wissen

# FIGURATIVE MAP of the successive losses in men of the French Army in the RUSSIAN CAMPAIGN OF 1812-1813

Drawn by Mr. Minard, Inspector General of Bridges and Roads in retirement, Paris, 20 November 1869. The numbers of men present are represented by the widths of the colored zones in a rate of one millimeter for ten thousand men; these are also written beside the zones. Red designates men moving into Russia, black those on retreat. — The informations used for drawing the map were taken from the works of Messrs. Chiers, de Ségur, de Fenezac, de Chambray and the unpublished diary of Jacob, pharmacist of the Army since 28 October. In order to facilitate the judgement of the eye regarding the diminution of the army, I supposed that the troops under Prince Jérôme and under Marshal Davoust, who were sent to Minsk and Mobilow and who rejoined near Orscha and Witebsk, had always marched with the army.

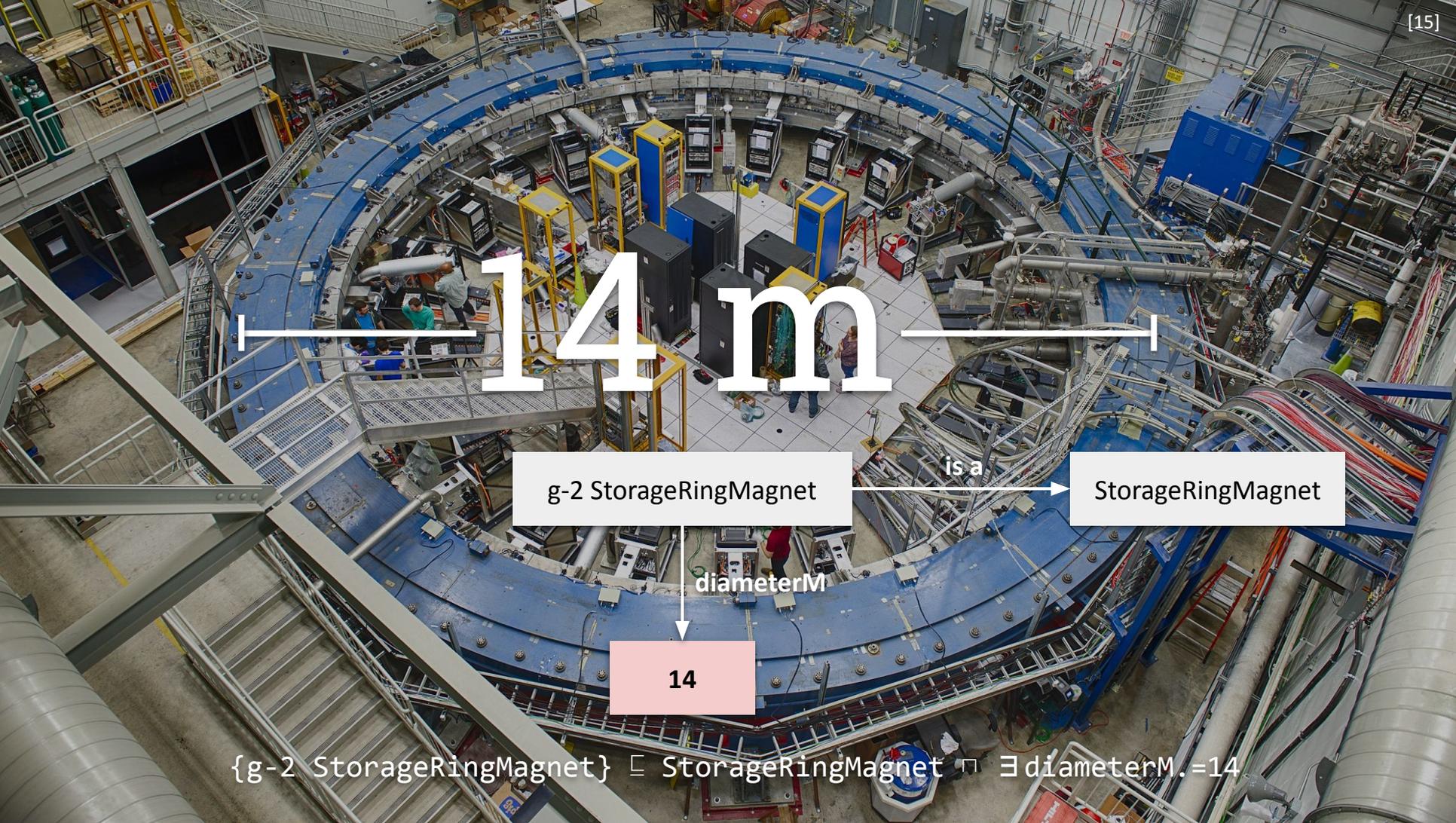


Event  $\sqsubseteq$   $\exists$  location.Location  $\sqcap$   $\exists$  agent.Agent  
 Location  $\sqsubseteq$   $\exists$  longitude. $\top$   $\sqcap$   $\exists$  latitude. $\top$

{Event1812-11-14}  $\sqsubseteq$  Event  $\sqcap$   $\exists$  location.{Smolensk}  $\sqcap$   
 $\exists$  agent.{LaGrandeArmée}  $\sqcap$   
 $\exists$  date.{1812-11-14 ~xsd:date}  $\sqcap$   
 $\exists$  survivors.{24000}  $\sqcap$   $\exists$  tempReamur.{-21}

Agent(LaGrandeArmée)  
 Person(NapoleonBonaparte)  
 agent(Event1812-11-14, LaGrandeArmée)  
 commands(NapoleonBonaparte, LaGrandeArmée)

The Cossacks pass the frozen Niemen at a gallop



14 m

g-2 StorageRingMagnet

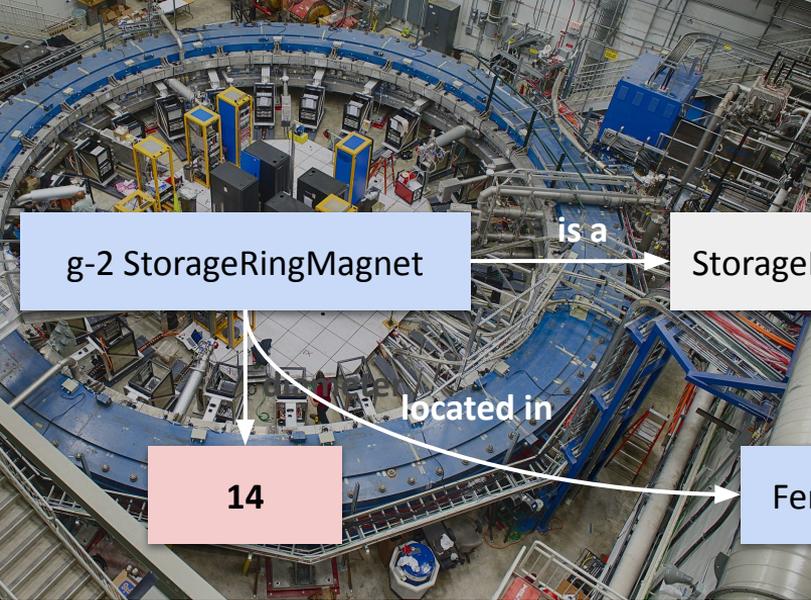
StorageRingMagnet

is a

diameterM

14

{g-2 StorageRingMagnet} ⊆ StorageRingMagnet ⊃ ∃ diameterM.=14



g-2 StorageRingMagnet

is a

StorageRingMagnet

part of

Experiment

Exhibit

14

located in

FermiLab

located in

conducted at

Laboratory

→ ≠ ←

Gallery

exhibited at

located in

Batavia, Illinois

located in

Location

is a

located in

```
{g-2 StorageRingMagnet} ⊆ StorageRingMagnet ⊧ ∃ diameterM.=14 ⊧ ∃ locatedIn.{FermiLab}
{FermiLab} ⊆ Laboratory ⊧ ∃ locatedIn.{BataviaIllinois}
Location(BataviaIllinois)
```

```
StorageRingMagnet ⊆ Thing
Laboratory ⊆ Thing
Gallery ⊆ Thing
```

```
locatedIn(Thing, Location)
partOf(StorageRingMagnet, Experiment)
Laboratory ⊧ Gallery ≡ ∅
```

```
conductedAt(Experiment, Laboratory)
exhibitedAt(Exhibit, Gallery)
```



# Vernetzte Forschungsdaten

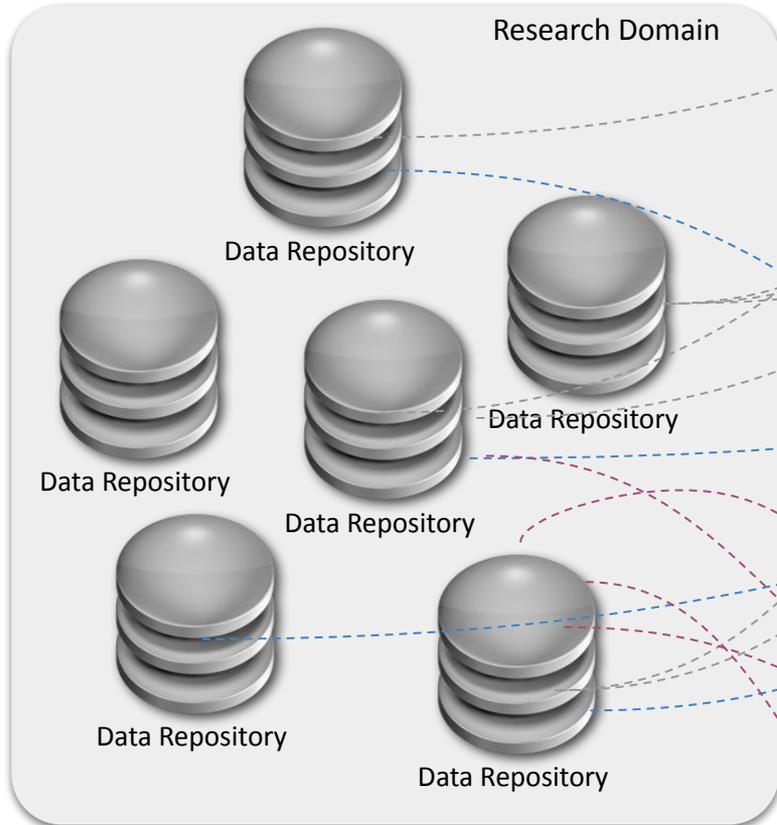


- **Standardisierung** von Metadaten
- Nutzung von **Normdaten** →
- **Ontologien** und semantische Technologien
- **Wissensgraphen**
- Umsetzung der **FAIR Prinzipien**
  - **F**indability
  - **A**ccessibility
  - **I**nteroperability
  - **R**eusable



# FAIR Research Data Management

with Ontologies and Knowledge Graphs



## Knowledge Graphs

Implement all 4 FAIR Principles

- **F**indability
- **A**ccessibility
- **I**nteroperability und
- **R**eproducibility

for Research Data Management

Knowledge Graph 1

Knowledge Graph 2



# Problem 2: Vollständigkeit und Updatezyklen Revisited...

# time travel (Q182154)

concept of moving between different points in time  
 chronoportation

[edit](#)

## ▼ In more languages

Configure

Language	Label	Description	Also known as
English	time travel	concept of moving between different points in time	chronoportation
German	Zeitreise	ungewöhnliche, teilweise theoretisch mögliche Bewegung durch die Zeit	Zeitsprung Zeitreisen
French	voyage dans le temps	thématique de science fiction	machine à voyager dans le temps voyage temporel machine à remonter le temps remonter le temps
Bavarian	No label defined	No description defined	

All entered languages

## Statements

instance of



superpower

[edit](#)

▼ 0 references

+ add reference



hypothesis

[edit](#)

▼ 0 references

+ add reference

+ add value

subclass of



motion

[edit](#)

▼ 0 references

+ add reference



fictional event

[edit](#)

▼ 0 references

+ add reference

+ add value



- Vokabulare, Metadaten, Normdaten & Wissensgraphen müssen sich laufend an Veränderungen anpassen.
- Typische Standardisierungszyklen sind zu lang.
- Die gesamte Nutzergemeinschaft sollte dabei mithelfen können.

## time travel (Q182154)

concept of moving between different points in time  
 chronoportation [edit](#)

▼ In more languages

[Configure](#)

Language	Label	Also known as
English	time travel	points in chronoportation
German	Zeitreise	theoretische, teilweise theoretisch mögliche Bewegung durch die Zeit
French	voyage dans le temps	thématique de science-fiction de voyager dans le temps voyage temporel machine à remonter le temps remonter le temps
Bavarian		isn't defined

All entered languages

### Statements

instance of	<div><span>Q182154</span> <span>superpower</span> <span><a href="#">edit</a></span></div> <div>▼ 0 references</div> <div><a href="#">+ add reference</a></div>
	<div><span>Q182154</span> <span>hypothesis</span> <span><a href="#">edit</a></span></div> <div>▼ 0 references</div> <div><a href="#">+ add reference</a></div>
<a href="#">+ add value</a>	

subclass of	<div><span>Q182154</span> <span>motion</span> <span><a href="#">edit</a></span></div> <div>▼ 0 references</div> <div><a href="#">+ add reference</a></div>
	<div><span>Q182154</span> <span>fictional event</span> <span><a href="#">edit</a></span></div> <div>▼ 0 references</div> <div><a href="#">+ add reference</a></div>
<a href="#">+ add value</a>	



## ● Probleme mit Wikibase:

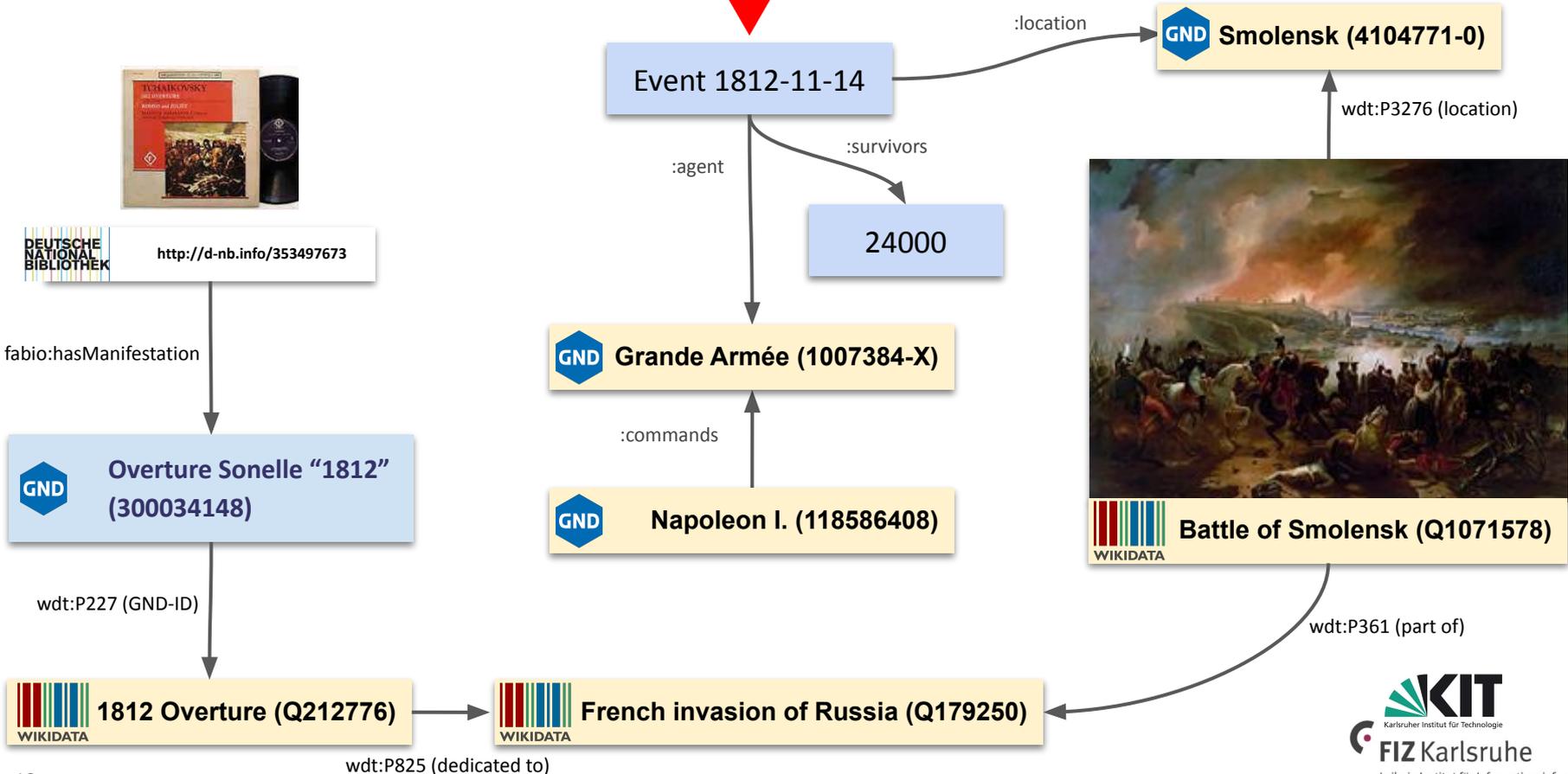
- Eingeschränkte Vernetzbarkeit
- kein W3C konformes Vokabular (RDF, RDFS, OWL) nutzbar
- keine **explizite Semantik** (damit auch kein **Reasoning** möglich)
- kein dezidiertes **Rechte- und Zugriffsmanagement**
- komplexe Architektur erfordert **aufwändige Anpassungen**
- Abhängigkeit von Wikimedia Foundation



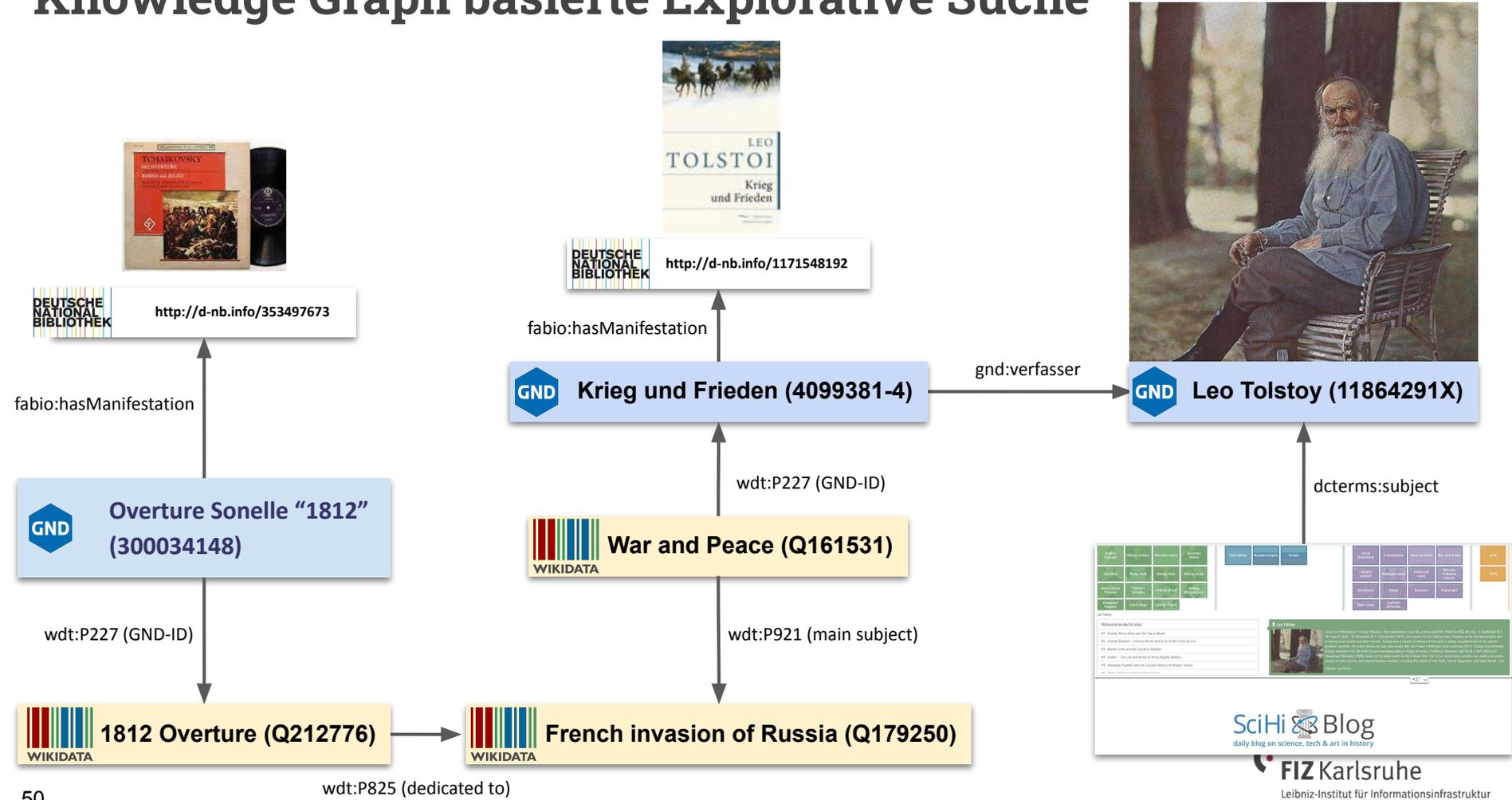
## Innovative Informationssysteme

- Verbessertes Retrieval
- Föderierte Suche
- Semantische Suche
- **Explorative Suche**
- Ähnlichkeitsbasierte Suche
- **Intelligente Empfehlungen**

# Knowledge Graph basierte Explorative Suche

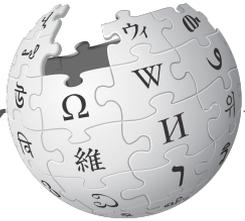


# Knowledge Graph basierte Explorative Suche

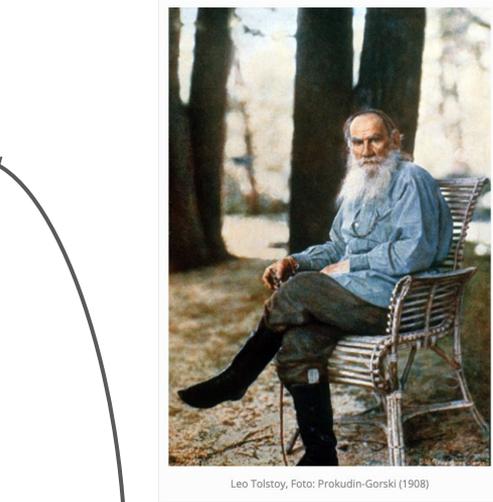


# Knowledge Graph basierte Explorative Suche

<http://scih.org/>



DBpedia



Leo Tolstoy, Foto: Prokudin-Gorski (1908)

On September 9, 1828, Russian writer Count **Ljov (also Lev) Nikolayevich Tolstoy**, usually referred to in English as **Leo Tolstoy**, was born. Tolstoy is considered one of the greatest authors of all times. His main works **War and Peace** and **Anna Karenina** are classics of the realistic novel.

**War and Peace**  
*War and Peace* (Pre-reform Russian: «Война и мир», *Voyna i mir*) is a novel by the Russian author Leo Tolstoy, first published in 1869. The

**media type** Hardcover

**literary genre** Historical novel

**author** Leo Tolstoy

**literary genre** Philosophical fiction

**literary genre** Romance novel

**publisher** The Russian Messenger

...another, each unhappy family is unhappy in its own

...1877), first sentence

...n noble Tolstoy family. He was the fourth of five children. His

...ch Tolstoy (1794-1837), his mother Marija Nikolajewna, née

...he became an orphan at the age of nine, his father's sister

...ying oriental languages at the University of Kazan in 1844.

After a change to the law faculty, he discontinued his studies in 1847 in order to improve the situation of

via refer.cx WordPress Plugin at <http://scih.org/>

15 Recommended Articles:

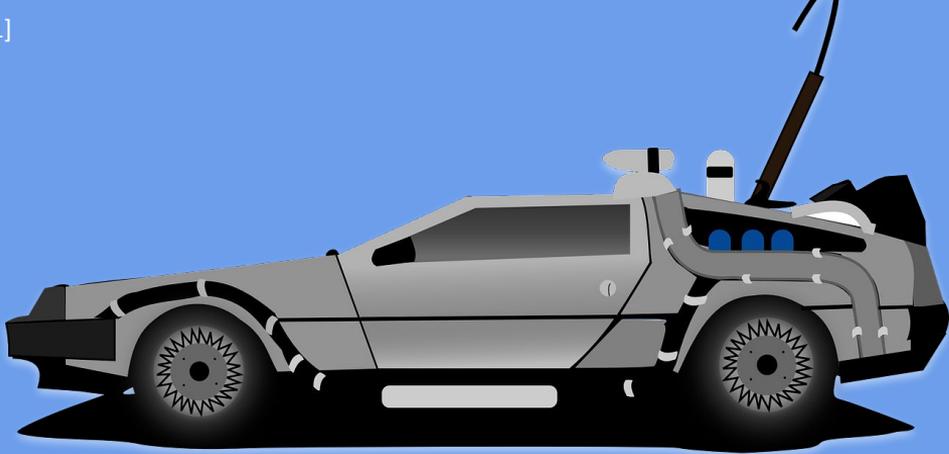
- #1 Charles Percy Snow and the Two Cultures
- #2 Charles Dickens – Famous Writer and Critic of the Victorian Era
- #3 Maxim Gorky and the Socialist Realism
- #4 Gothic – The Life and Works of Percy Bysshe Shelley
- #5 Alexander Pushkin and the Cultural Identity of Modern Russia
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“Die Welt ist klein und man trifft sich immer zweimal...”

oder

Forschungsdateninfrastrukturen und die Renaissance der Normdaten

Prof. Dr. Harald Sack

GNDCon 2.0, Frankfurt, 7. Juni 2021

Twitter: <https://twitter.com/lysander07>

## Take Home Messages:

- **Intelligente Informationssysteme** sind immer (noch) ein wichtiges Forschungsthema.
- Die **Vernetzung von Daten, Informationen und Wissen** wird immer wichtiger.
- **Ontologien und Wissensgraphen** helfen bei der effektiven Umsetzung der **FAIR Prinzipien**.
- Die **NFDI** bietet die Chance der großflächigen (intelligenten) Vernetzung von Forschungsdaten.
- **Normdaten**, wie die GND werden dabei eine wichtige Rolle spielen.

## Image References:

- [1] De Lorean Time Machine, pixabay, Public Domain, <https://pixabay.com/de/vectors/delorean-auto-time-machine-38103/>
- [2] Semantic Technologies Research Group at HPI, 2011, all rights reserved
- [3] 16mm film canisters, The National Film and Sound Archive's collection, CC-BY-NC-ND 2.0, <https://www.flickr.com/photos/nfsa/6393007611>
- [4] Visual film analysis, T. Osterhoff, Semantic Media Explorer, 2012, all rights reserved
- [5] yovisto video search engine, 2011, some rights reserved
- [6] Dr. Marcus Gossler (Own work) [GFDL (<http://www.gnu.org/copyleft/fdl.html>) or CC-BY-SA-3.0 (<http://creativecommons.org/licenses/by-sa/3.0/>) ]
- [7] Information Service Engineering research group, 2019, Johannes Hüscher, all rights reserved
- [8] Matrix Computer Screen, [pixabay license https://pixabay.com/illustrations/matrix-code-computer-pc-data-356024/](https://pixabay.com/illustrations/matrix-code-computer-pc-data-356024/)
- [9] UBC Library Card Catalog, Paul Joseph, cc-by-2.0, [https://commons.wikimedia.org/wiki/File:2009\\_3544505541\\_card\\_catalog.jpg](https://commons.wikimedia.org/wiki/File:2009_3544505541_card_catalog.jpg)
- [10] Tree of knowledge based on the French Encyclopedie from 1780, public domain, [https://commons.wikimedia.org/wiki/File:Essai\\_d%27une\\_distribution\\_g%C3%A9n%C3%A9alogique\\_des\\_sciences\\_et\\_des\\_arts\\_principaux\\_1780.jpg](https://commons.wikimedia.org/wiki/File:Essai_d%27une_distribution_g%C3%A9n%C3%A9alogique_des_sciences_et_des_arts_principaux_1780.jpg)
- [11] Pieter Bruegel the Elder, The Tower of Babel, 1563, public domain, [https://commons.wikimedia.org/wiki/File:Pieter\\_Bruegel\\_the\\_Elder\\_-\\_The\\_Tower\\_of\\_Babel\\_\(Vienna\)\\_-Google\\_Art\\_Project\\_-\\_edited.jpg](https://commons.wikimedia.org/wiki/File:Pieter_Bruegel_the_Elder_-_The_Tower_of_Babel_(Vienna)_-Google_Art_Project_-_edited.jpg)
- [12] Charles Minard's 1869 chart showing the number of men in Napoleon's 1812 Russian campaign army, public domain, <https://commons.wikimedia.org/wiki/File:Minard.png>
- [13] Silos, CCO, <https://pxhere.com/en/photo/773866>
- [14] Globale Digitalisierung, public domain, <https://www.publicdomainpictures.net/pictures/380000/velka/globale-digitalisierung-201105.jpg>
- [15] The E989 storage-ring magnet at Fermilab, which was originally designed for the E821 experiment. Photo: Glucikov @ WikimediaCommons [cc-BY-SA 4.0] [https://commons.wikimedia.org/wiki/File:Fermilab\\_g-2\\_\(E989\)\\_ring.jpg](https://commons.wikimedia.org/wiki/File:Fermilab_g-2_(E989)_ring.jpg)
- [16] De Lorean Time Machine, Wikimedia, [https://commons.wikimedia.org/wiki/File:TeamTimeCar.com-BTTF\\_DeLorean\\_Time\\_Machine-OtoGodfrey.com-JMortonPhoto.com-04.jpg](https://commons.wikimedia.org/wiki/File:TeamTimeCar.com-BTTF_DeLorean_Time_Machine-OtoGodfrey.com-JMortonPhoto.com-04.jpg)