

Fraunhofer
Dresden IAIS

Knowledge Graphs

In Conversational AI Platforms

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Fraunhofer IAIS & Smart Data Analytics
Dresden

Outline

Background

NLP, NLU, KGs & Conversational AI

- The Mushroom Effect

The SPEAKER Platform



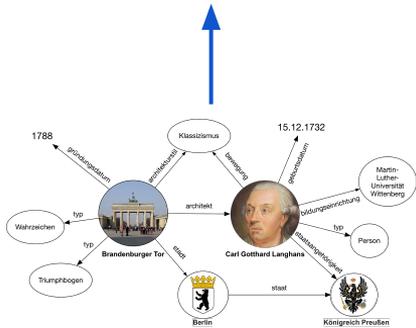
Background

We build conversational AI platforms

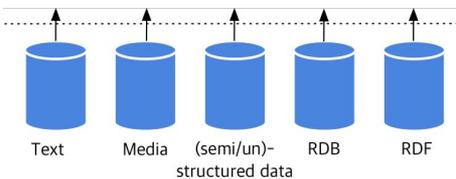


Background

We build conversational AI platforms



Powered by knowledge graphs



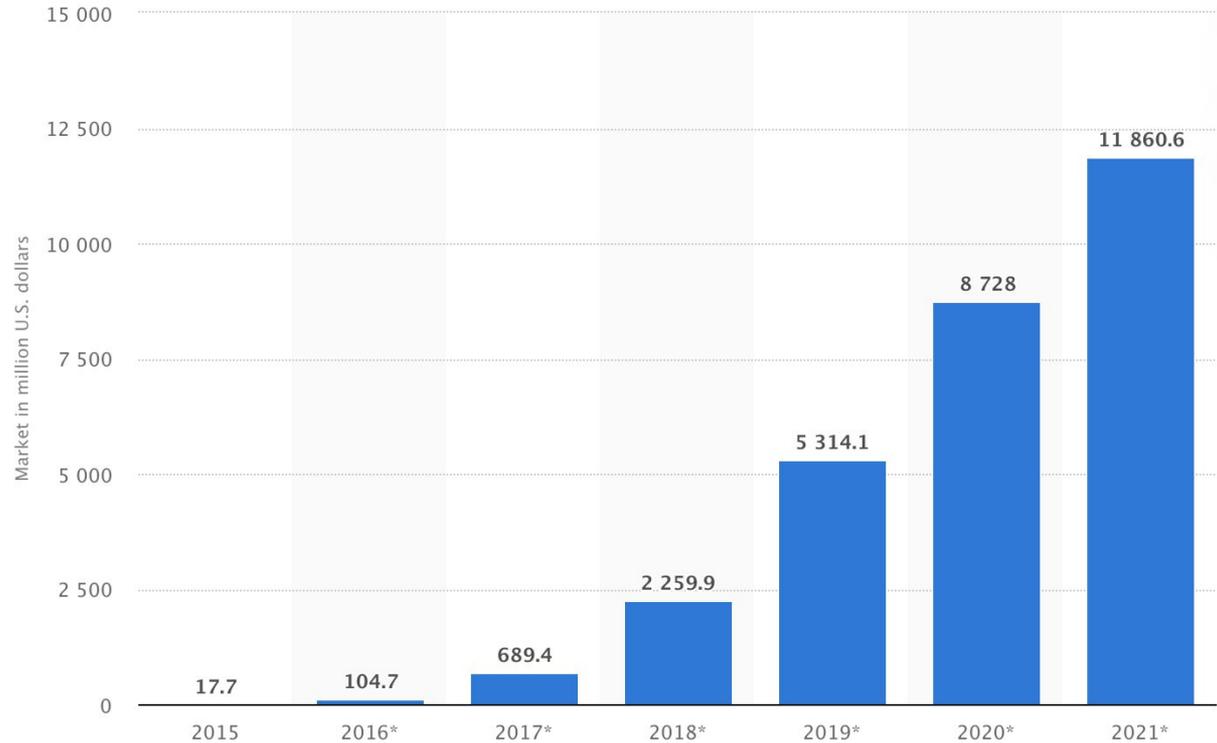
Obtained by integrating heterogeneous data

Background

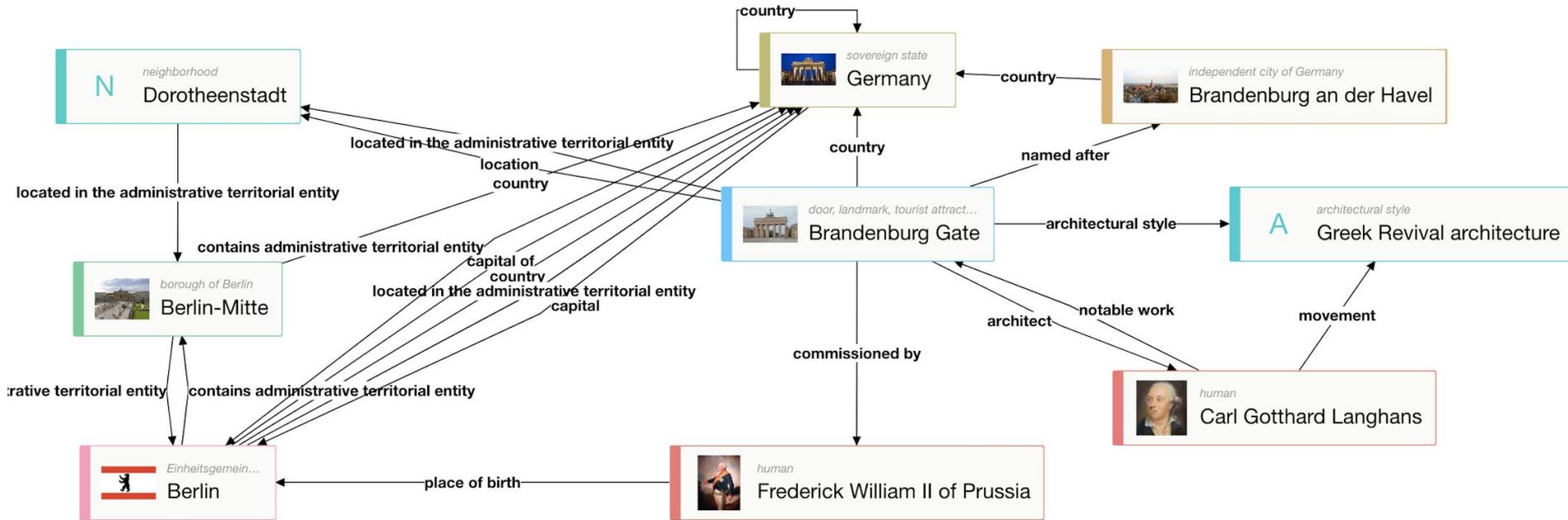
- Speech and text are the most natural interfaces
- Dialogue systems become a standard communication interface

Size of the consumer virtual digital assistant (VDA) market worldwide from 2015 to 2021

(in million U.S. dollars)



Knowledge Graph



<https://wikidata.metaphacts.com>

What's available

Knowledge Graphs

Open-domain: Wikidata, DBpedia

Biomed: Drugbank, SNOMED-CT, Bio2RDF

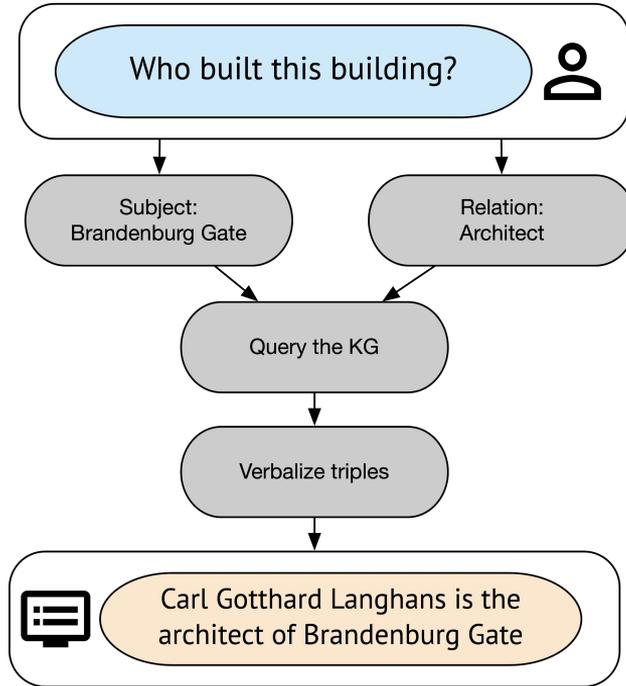
Ontologies

Industry 4.0: RAMI

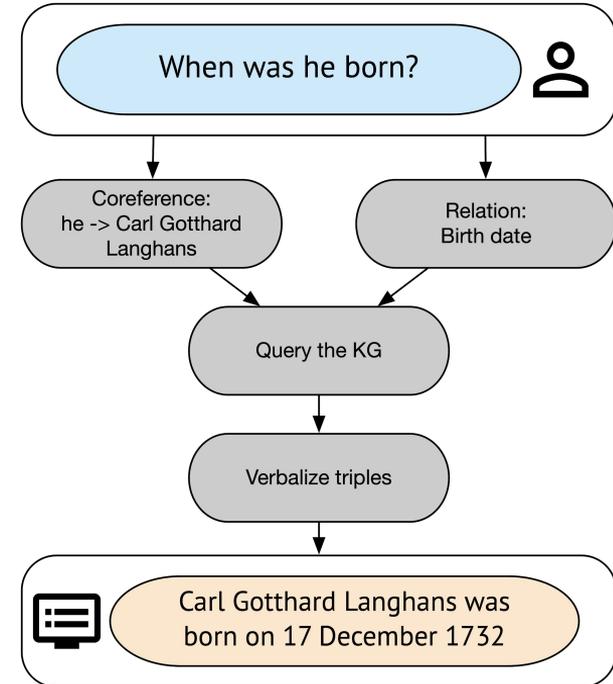
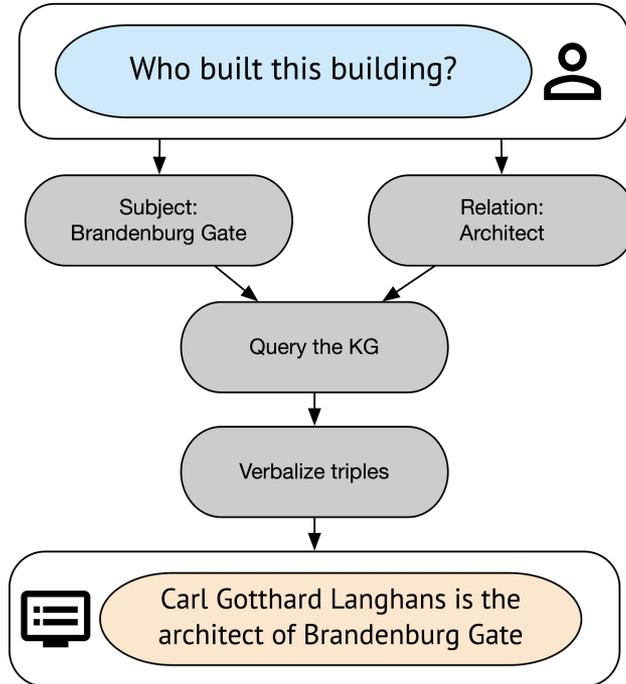
Finance: FIBO, FRO, XBRL, FinReg

etc

What's possible - Question Answering



What's possible - Dialogues



Knowledge graph-based dialogue systems

Relation linking	#
Predicates	131
Training examples	52122

- Knowledge graph schema can be small, but training data has to be large (> 10 000 data points)
 - Less data -> rule-based systems are preferred

Knowledge graph-based dialogue systems

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- Knowledge graph schema can be small, but training data has to be large (> 10 000 data points)
 - Less data -> rule-based systems are preferred
- Dialogue \neq QA
 - Goal-oriented and particular context
 - Dialogue state (context) has to be memorized

We signed a contract with
X last week.

Great

How many employees
work there?

Mushrooms?



Berlin Hbf

What is this building?

Q

Mushrooms?



What is this building?

Q

A

This is Berlin Hauptbahnhof

Mushrooms?



Berlin Hbf

What is this building?

Q

A

This is Berlin Hauptbahnhof

What is its architectural style?

Q

What is its architectural style?



What is

architectural style?

WIKIPEDIA Free Encyclopedia

Article Talk

Berlin Hauptbahnhof

From Wikipedia, the free encyclopedia
(Redirected from Berlin Hbf)

For the station known as Berlin Hauptbahnhof between 1987 and 1998, see *Berlin Ostbahnhof*.

This article includes a list of references, but its sources remain unclear because it has insufficient inline citations. Please help to improve this article by introducing more precise citations. (January 2012) *(Learn how and when to remove this template message)*

Berlin Hauptbahnhof (listen[ⓘ]) (English: **Berlin Central Station**^[de]^[en]^[fr]) is the main railway station in Berlin, Germany^[de]^[en]. It came into full operation two days after a ceremonial opening on 26 May 2006. It is located on the site of the historic **Lehrter Bahnhof**, and until it opened as a main line station, it was a stop on the Berlin S-Bahn suburban railway temporarily named **Berlin Hauptbahnhof-Lehrter Bahnhof**. The station is operated by DB Station&Service, a subsidiary of Deutsche Bahn AG, and is classified as a Category 1 station, one of 21^[10] in Germany and four in Berlin, the others being Berlin Gesundbrunnen, Berlin Südkreuz and Berlin Ostbahnhof.

Berlin Hauptbahnhof (Lehrter Station) opened in 1871 as the terminus of the railway linking Berlin with Lehrte, near Hannover, which later became Germany's most important east-west main line. In 1882, with the completion of the *Stadtbahn* (City Railway) Berlin's four-track central elevated railway line, which carries both local and main line services), just north of the station, a smaller interchange station called **Lehrter Stadtbahnhof** (Hamburg Station), Lehrter Bahnhof became the terminus for trains to and from **Hamburg**, after the closure of nearby **Hamburger Bahnhof** (Hamburg Station). Lehrter Bahnhof continued as a stop on the S-Bahn. In 1987, it was extensively renovated to commemorate Berlin's 750th anniversary. After German reunification it was decided to improve Berlin's railway network by constructing a new north-south main line, to supplement the east-west Stadtbahn. Lehrter Stadtbahnhof was considered to be the logical location for a new central station.

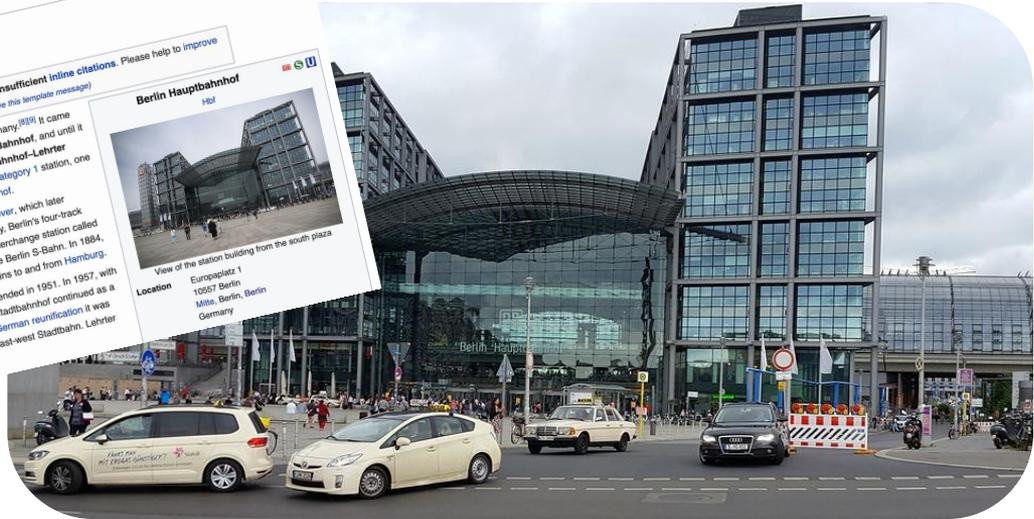
Following heavy damage during World War II, limited services to the main station were resumed, but then suspended in 1951. In 1957, the railways to West Berlin under the control of East Germany, Lehrter Bahnhof was demolished, but Lehrter Stadtbahnhof continued as a stop on the S-Bahn. In 1987, it was extensively renovated to commemorate Berlin's 750th anniversary. After German reunification it was decided to improve Berlin's railway network by constructing a new north-south main line, to supplement the east-west Stadtbahn. Lehrter Stadtbahnhof was considered to be the logical location for a new central station.

Berlin Hauptbahnhof



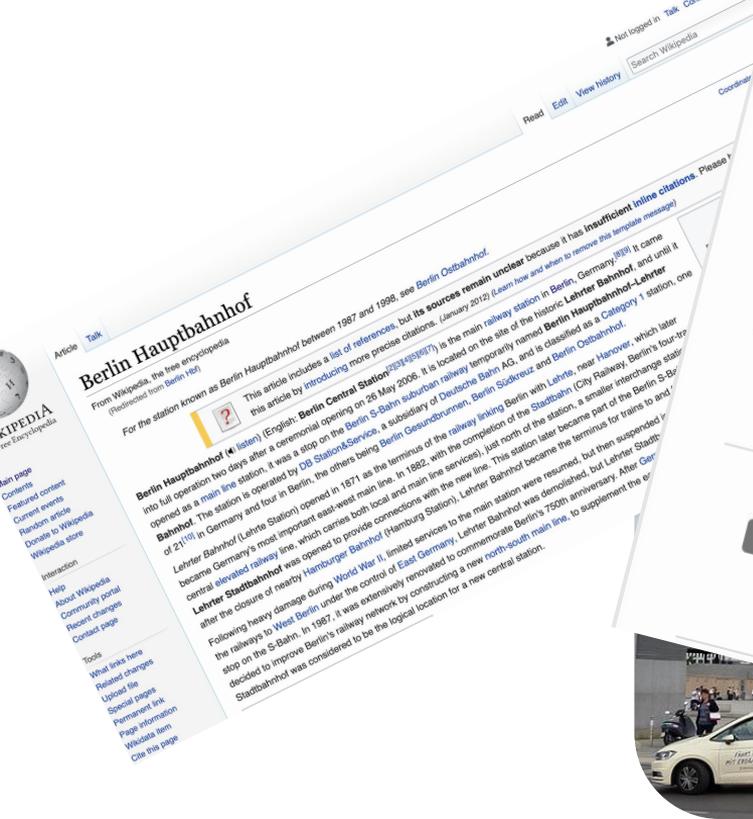
View of the station building from the south plaza

Location	Europaplatz 1 10567 Berlin Mitte, Berlin, Berlin Germany
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Wikipedia

Mikhail Galkin, AI Talk EU, 25.10.2019



Rank	Model	EM	F1
1 Mar 20, 2019	Human Performance Stanford University <i>(Rajpurkar & Jia et al. '18)</i>	86.831	89.452
2 Mar 15, 2019	BERT + DAE + AoA (ensemble) Joint Laboratory of HIT and iFLYTEK Research	87.147	89.474
3 Mar 05, 2019	BERT + ConvLSTM + MTL + Verifier (ensemble) Layer 6 AI	86.730	89.286
	BERT + N-Gram Masking + Synthetic Self-Training (ensemble) Google AI Language https://github.com/google-research/bert	86.673	89.147

Passage Retrieval(10/26/2018-Present)

Rank	Model	Ranking Style	Submission Date	MRR@10 On Eval	MRR@10 On Dev
1	Enriched BERT base + AOA index V1 Ming Yan	Full Ranking	May 13th, 2019	0.383	0.397
2	Enriched BERT base + AOA index V2 Ming Yan	Full Ranking	May 13th, 2019	0.380	0.389
3	BERT^2 (1)Rodrigo Nogueira, (2)Wei Yang, (3)Jimmy Lin, (4)Kyunghyun Cho - New York University(1,4), University of Waterloo(2,3), Facebook AI Research(4)	Full Ranking	May 13th, 2019	0.375	0.386
4	Enriched BERT base + AOA index Ming Yan	Full Ranking	May 6th, 2019	0.373	0.387
5	BERTter Indexing (1)Rodrigo Nogueira, (2)Wei Yang, (3)Jimmy Lin, (4)Kyunghyun Cho - New York University(1,4), University of Waterloo(2,3), Facebook AI Research(4) [Nogueira et al. '19] and [Code]	Full Ranking	April 8th, 2019	0.368	0.375

EM	F1
86.831	89.45
87.147	89.474
86.730	89.286
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N-Gram Masking + Synthetic Self-
 Training (ensemble)
 Google AI Language
<https://github.com/google-research/bert>



Passage Retrieval(10/26/2018-Present)

Berlin
From Wikipedia (Redacted)
For the
Berlin I
into full
opene
Bahn
of 21
Lehr
bec
cer
Le
at
F
were
anges
ages
ent link
formation
ta term
us page

Rank	Model
1	Enriched BERT b
2	Enriched BERT t
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4	Enriched BEF
5	BERTter Inc New York U et al. '19] a

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	May 13th, 2019	0.380	0.389
			0.386

Leaderboard (Fullwiki Setting)

In the *fullwiki* setting, a question-answering system must find the answer to a question in the scope of the entire Wikipedia. Similar to in the *distractor* setting, systems are evaluated on the accuracy of their answers (Ans) and the quality of the supporting facts they use to justify them (Sup).

Rank	Model	Code	Ans		Sup		Joint	
			EM	F ₁	EM	F ₁	EM	F ₁
1	Cognitive Graph QA (single model) <i>Tsinghua KEG & Alibaba DAMO Academy</i> Ding et al., ACL'19		37.12	48.87	22.82	57.69	12.42	34.92
2	MUPPET (single model) <i>Anonymous</i>		30.61	40.26	16.65	47.33	10.85	27.01
3	GRN + BERT (single model) <i>Anonymous</i>		29.87	39.14	13.16	49.67	8.26	25.84
4	GRN (single model) <i>Anonymous</i>		27.34	36.48	12.23	48.75	7.40	23.55

Rank	Model	EM	F ₁
1		86.831	89.45
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Mushrooms!



What is this building?

Q

A

This is Berlin Hauptbahnhof

What is its architectural style?

Q

A

Mushroom



Mushrooms!

What is its architectural style?



Function [\[edit \]](#)

The Berlin Hauptbahnhof is part of the **mushroom** concept that was being made in Berlin, in which the station forms as a connecting point for converging and intersecting lines, of different modes of public transport there.

Planning the new station [\[edit \]](#)

Soon after the fall of the [Berlin Wall](#) in 1989, city planners began work on a transport plan for reunified Berlin. One element of this became the "Pilzkonzept" (**mushroom** concept), in which a new north-south railway line intersecting the Stadtbahn was to be constructed. The name derived from the shape formed by the new line and existing lines, which vaguely resembles a **mushroom**.

Mushrooms!

What is its architectural style?



Function [\[edit \]](#)

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- ✓ its = Berlin Hauptbahnhof
- ✓ In Berlin
- ✓ Concept ~ Style

- ✗ Applicable to the city concept, not architectural style of the station
- ✗ Close, but not correct



With KG flavors

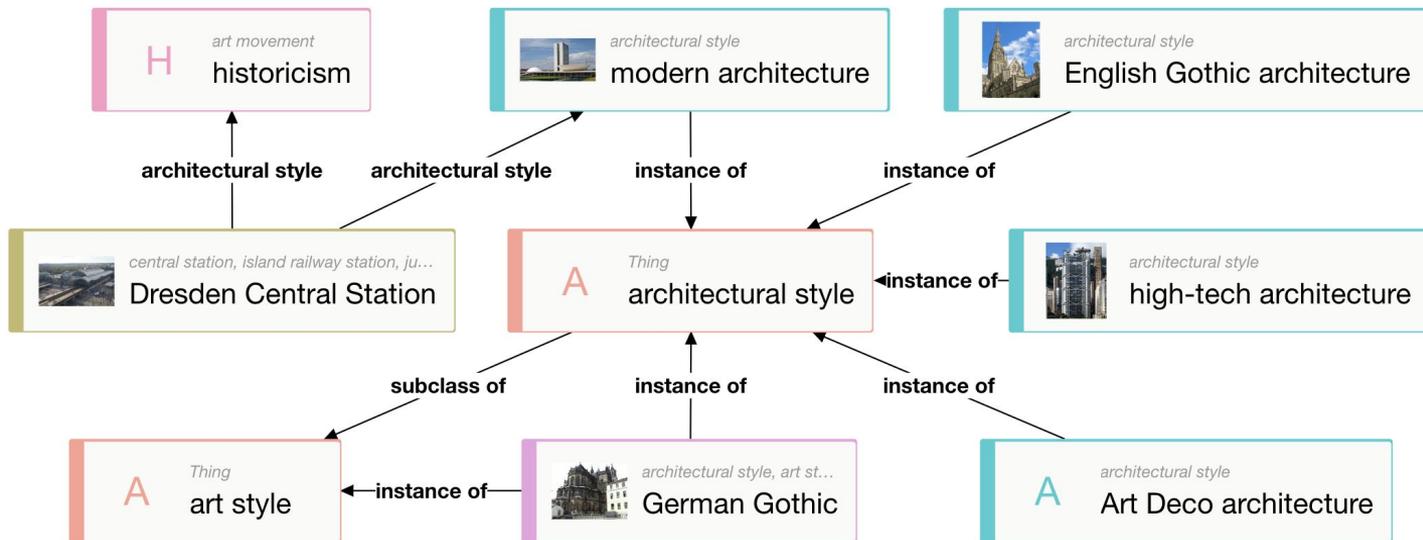
Can mushrooms be
an architectural
style?



With KG flavors

Can mushrooms be
an architectural
style?

Probably not



So why you need graphs?

How many children
does Berlin Hbf have?

Implicit or explicit constraints on produced answers

So why you need graphs?

How many children
does Berlin Hbf have?

Train stations
don't have kids

Implicit or explicit constraints on produced answers

- reduce candidates space
- help to fight the mushroom effect
- **ontologies help**

So why you need graphs?

How many children
does Berlin Hbf have?

Train stations
don't have kids

What is the busiest
train station in
Germany?

Implicit or explicit constraints on produced answers

- reduce candidates space
- help to fight the mushroom effect
- **ontologies help**

Complex QA via (sub)graphs aggregations

So why you need graphs?

How many children does Berlin Hbf have?

Train stations don't have kids

What is the busiest train station in Germany?

Hamburg Hbf

Implicit or explicit constraints on produced answers

- reduce candidates space
- help to fight the mushroom effect
- **ontologies help**

Complex QA via (sub)graphs aggregations

```
select ?station ?visits where {  
  ?station wdt:P31 wd:Q18543139 .      # central stations  
  ?station wdt:P17 wd:Q183 .          # in Germany  
  ?station wdt:P1373 ?visits .        # daily visits  
} ORDER BY DESC(?visits) LIMIT 1     # sort
```

So why you need graphs?

Takeaway 1

Graphs significantly improve reasoning compared to sole natural language inference

So why you need graphs?

Takeaway 1

Graphs significantly improve reasoning compared to sole natural language inference

Takeaway 2

Reasoning outcomes are **explainable** and traceable

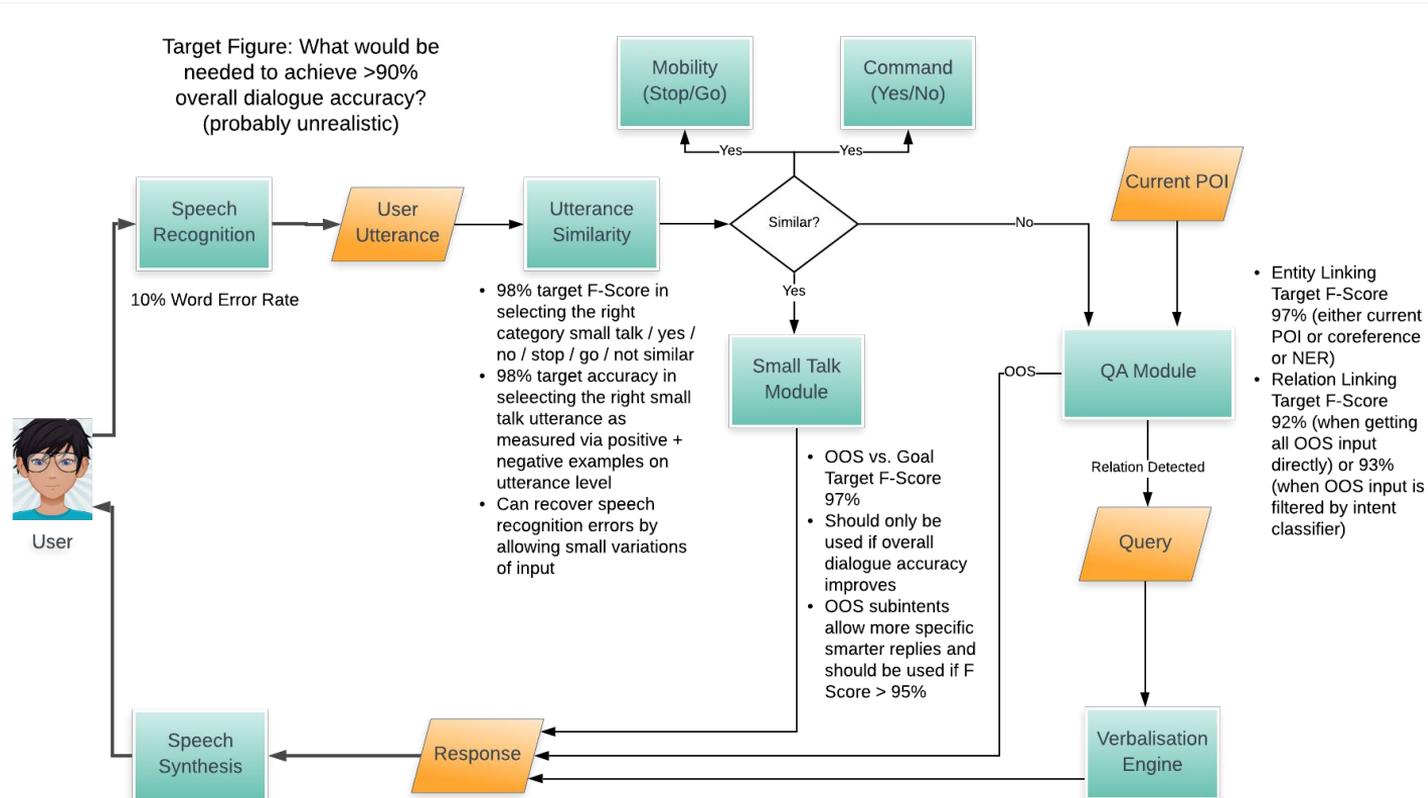
KDDS

Knowledge-driven
in-car dialogue
system (EN/DE)

Full DBpedia
2019 (wikidata
branch)

> 50M entities

> 4B triples



KDDS @ Hannover-Messe

Building KGs from enterprise
sources is still a challenge



KDDS @ Hannover-Messe

Building KGs from enterprise sources is still a challenge

Depth of knowledge vs variety of domains



KDDS @ Hannover-Messe

Building KGs from enterprise sources is still a challenge

Depth of knowledge vs variety of domains

Explainability is crucial



Fraunhofer IAIS

Standort Dresden

ML2R

National Competence Center for
Machine Learning Rhein-Ruhr

Fraunhofer Center for Machine Learning

IAIS-led part of Fraunhofer
Cluster of Excellence
Cognitive Internet
Technologies

CEE AI

Center for Explainable and Efficient AI
Technologies with TU Dresden



Fraunhofer-Alliance Big Data AI
The biggest Fraunhofer alliance
with > 30 institutes led by IAIS



AI4EU
EU Lighthouse
Project for AI



**International Data Spaces
Association**
Data sovereignty for Big
Data and AI, 100+
companies

SPEAKER

- ★ Digital sovereignty
 - Independent from Google, AWS
 - Compliant with German enterprise and user data protection regulations

- ★ B2B-oriented

SPEAKER

- ★ Conversational AI
 - Acoustic frontend
 - Speech recognition in DE & EN
 - Focus on integrating enterprise knowledge
 - Modular design

SPEAKER AI Platform



LEGENDE

- Use Case bzw. Partner Modul
- SPEAKER Modul
- Benchmarking
- Datenkonnektoren

SPEAKER Data Platform

Benchmarking



HOBbit



GERBIL



NLoop

Akademische/ Freie Trainingsdaten



ASR/
Sprachsynthese



Question/Answering
Query Building
Command Selection



NLU
(NER, NED, RE,
Intenterkennung)



Dialoge/Feedback

Industrielle Trainingsdaten



Intelligent Data Source Connectors



Industrial Data Sources



Datenbanken



Tabellen
(CSV, Excel,...)



Kommunikations-
kanäle



Business
Processes



IoT/Cloud
Speicher

SPEAKER Consortium

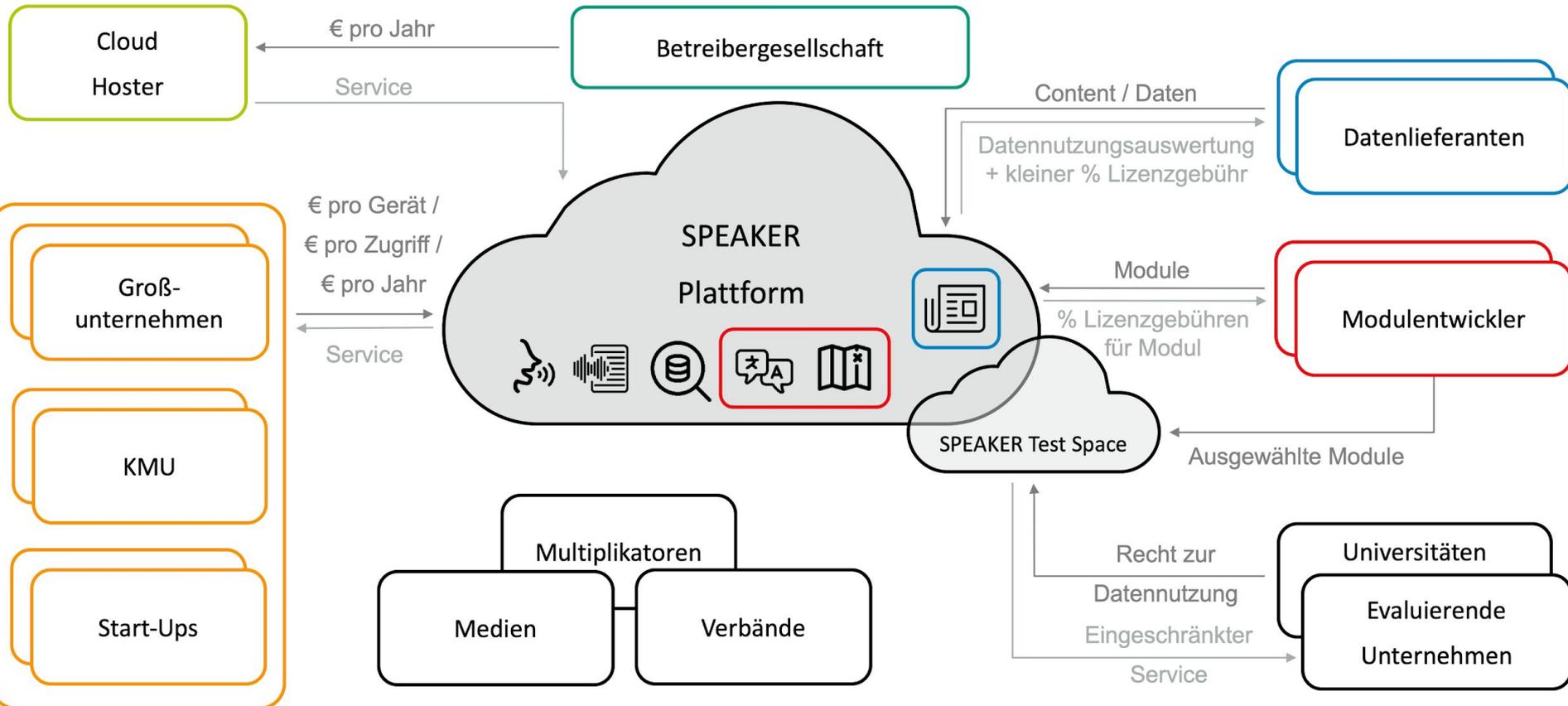
+ 31 Assoziierte Partner

+ 20 Verbundpartner

+ 5 KI-Innov. Proj.



SPEAKER Platform



SPEAKER Use-cases

Automotive

- Easy access to information about surroundings and landmarks
- Voice input & output increases driver safety
- Interactive city guides via natural dialogues



SPEAKER Use-cases



Disaster Management

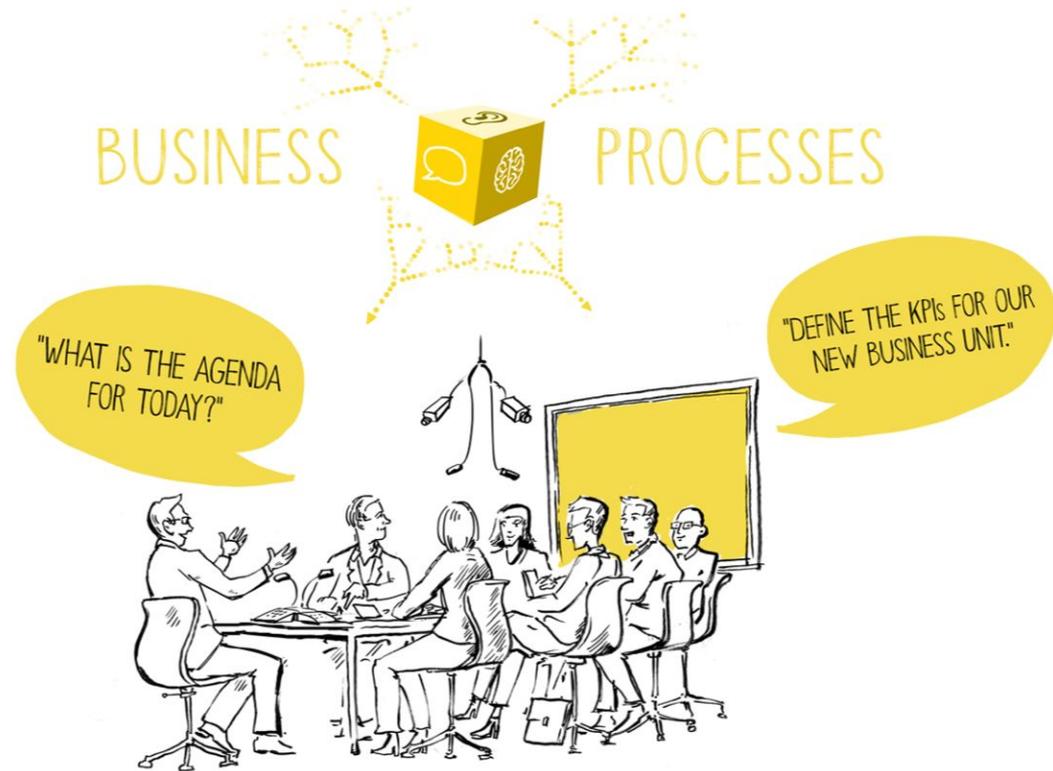
- Timeliness of response and remedy
- Optimization of resource planning and use
- Consistency of available information in real time



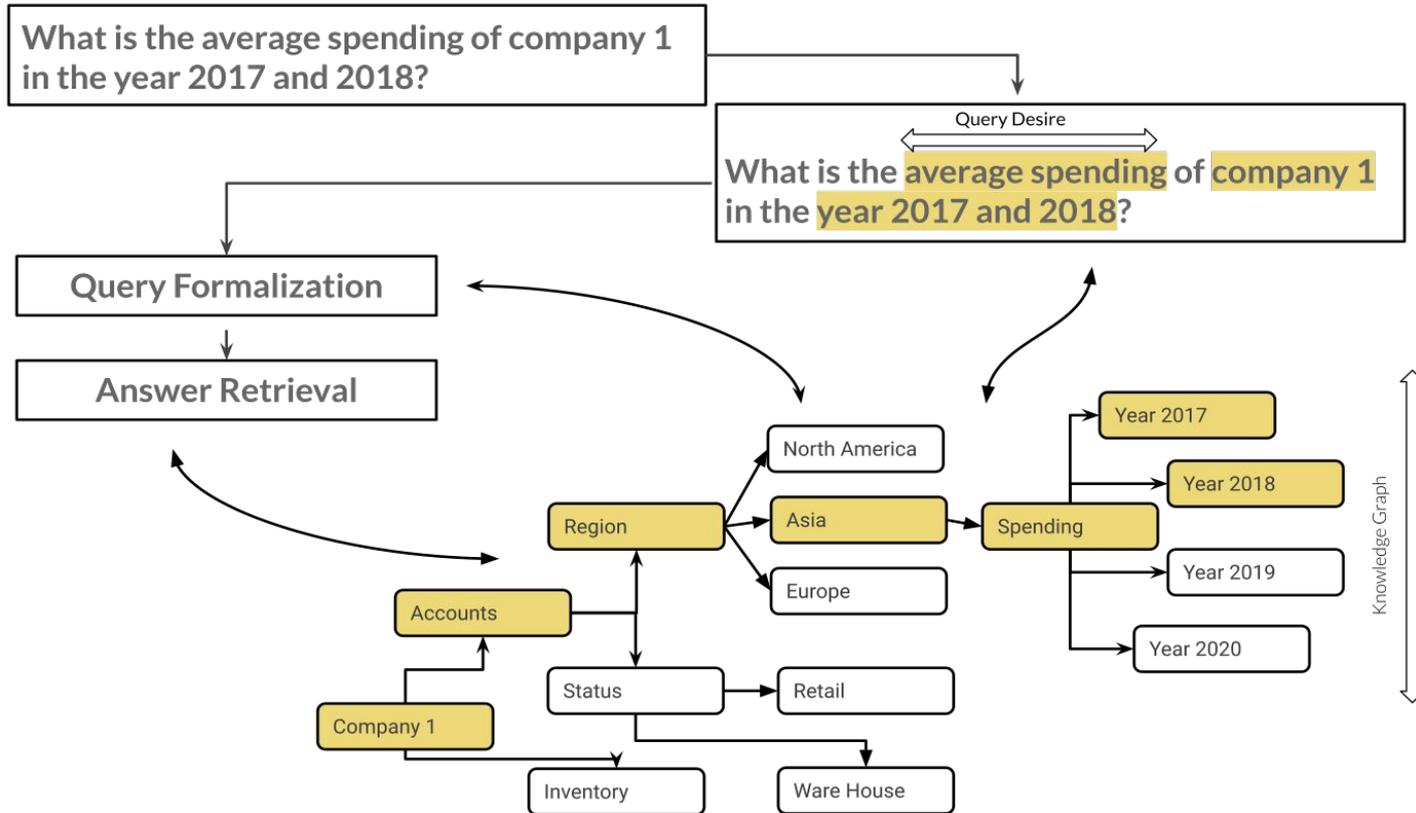
SPEAKER Use-cases

Business Processes

- Support and optimization for business and decision processes
- Comprehensive answers on the fly combining multiple data sources
- No need to search through files in the information system



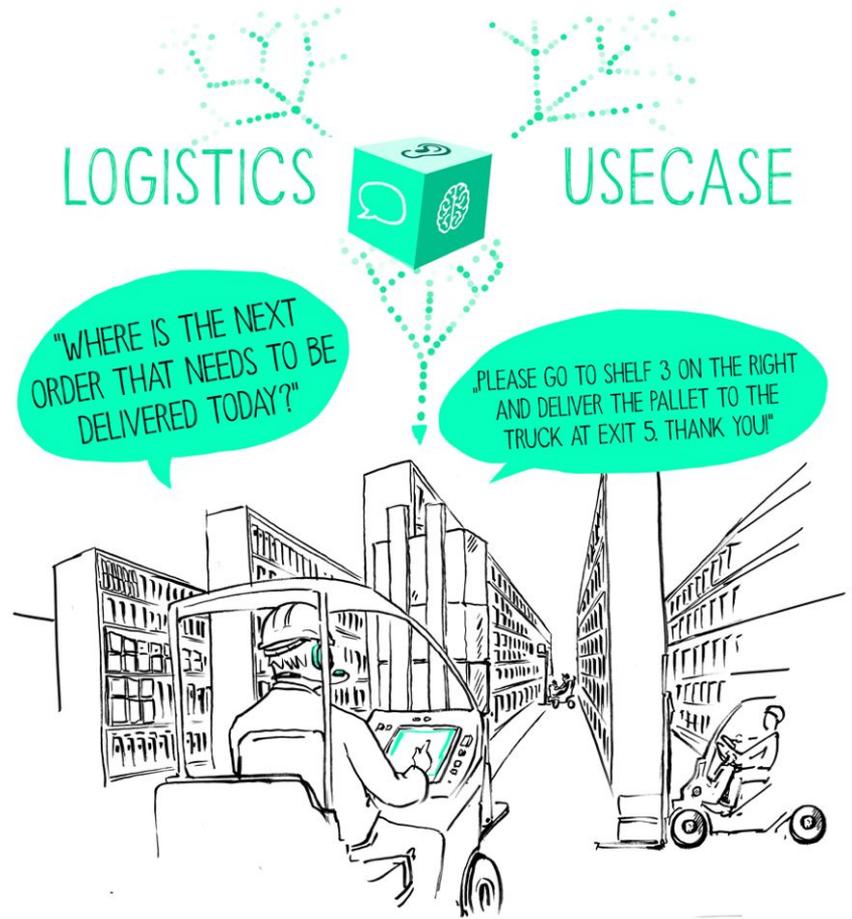
SPEAKER Use-cases - Financial QA



SPEAKER Use-cases

Logistics

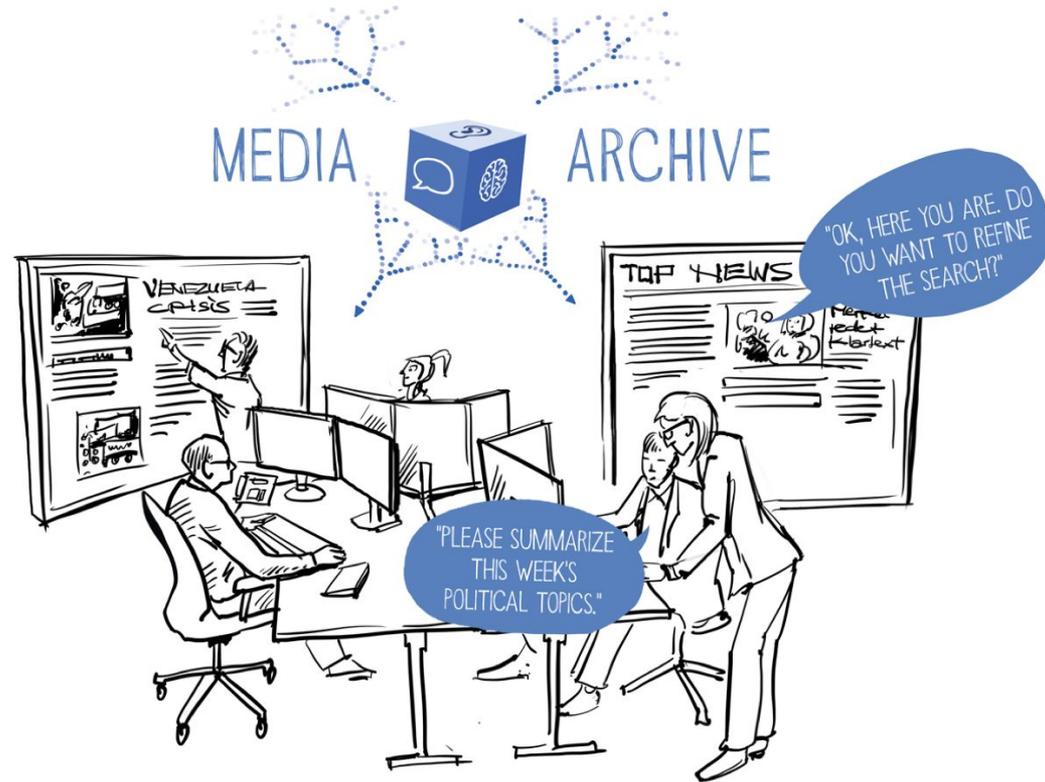
- Navigation through logistic centers or warehouses
- Low-barrier access to information and on the fly inferencing
- Time saving with less mistakes



SPEAKER Use-cases

Media Archive

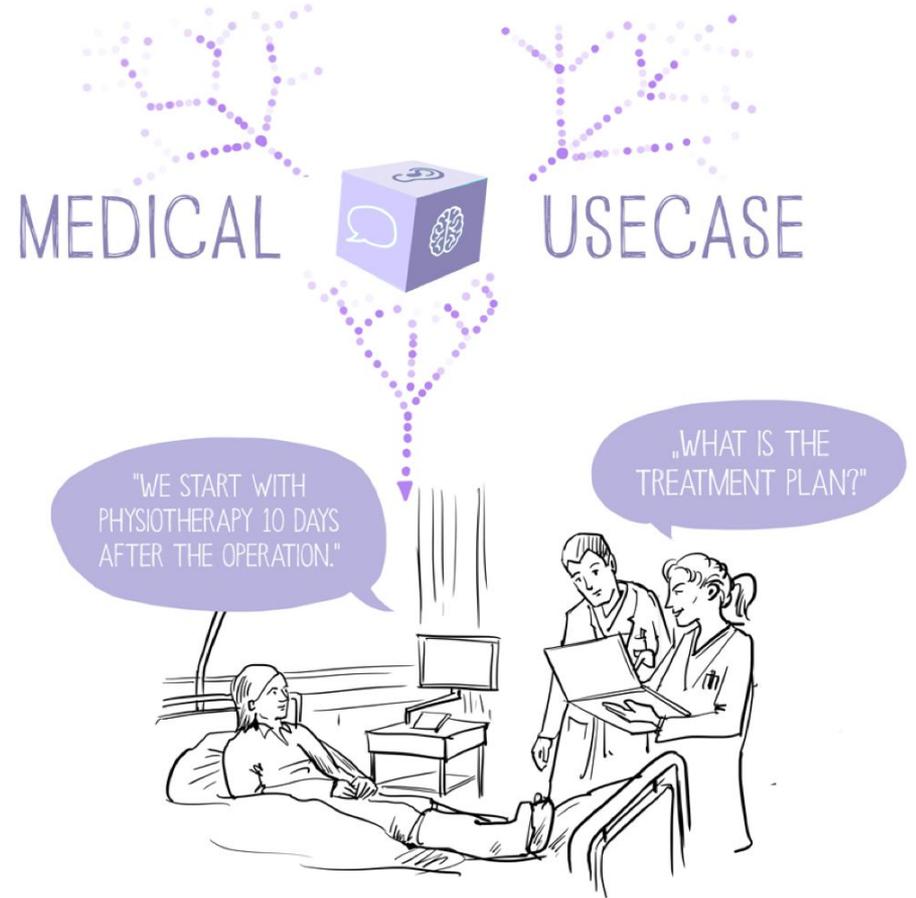
- Lightweight speech-based search for specific content
- Rapid orientation in massive amounts of media files
- Hands-free: intuitive and comfortable operation



SPEAKER Use-cases

Medical

- Reduced efforts for patient status reports
- Condensed natural language output combining multiple datasources
- Immediate access for efficient scheduling & treatment planning





Fraunhofer

Dresden

IAIS

Thank you!

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