



**Fraunhofer**

Dresden

IAIS



# The Mushroom Effect

Or Why You Need Knowledge Graphs for Dialogue Systems

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Fraunhofer IAIS & Smart Data Analytics  
**Dresden**

# Outline

Background

Mushrooms?

With KG Flavors

About us: CEE AI Dresden



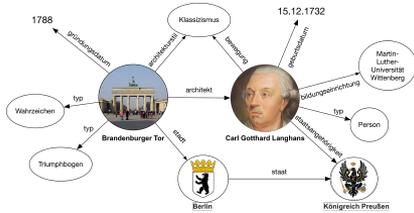
# Background

We build conversational AI platforms



# Background

We build conversational AI platforms

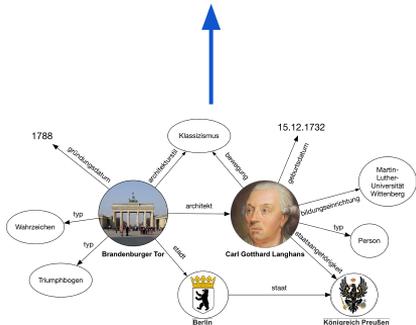


Powered by knowledge graphs

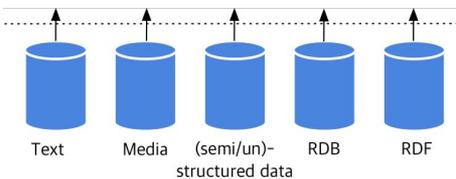


# Background

We build conversational AI platforms



Powered by knowledge graphs



Obtained by integrating heterogeneous data

# Mushrooms?



Berlin Hbf

What is this building?



# 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?

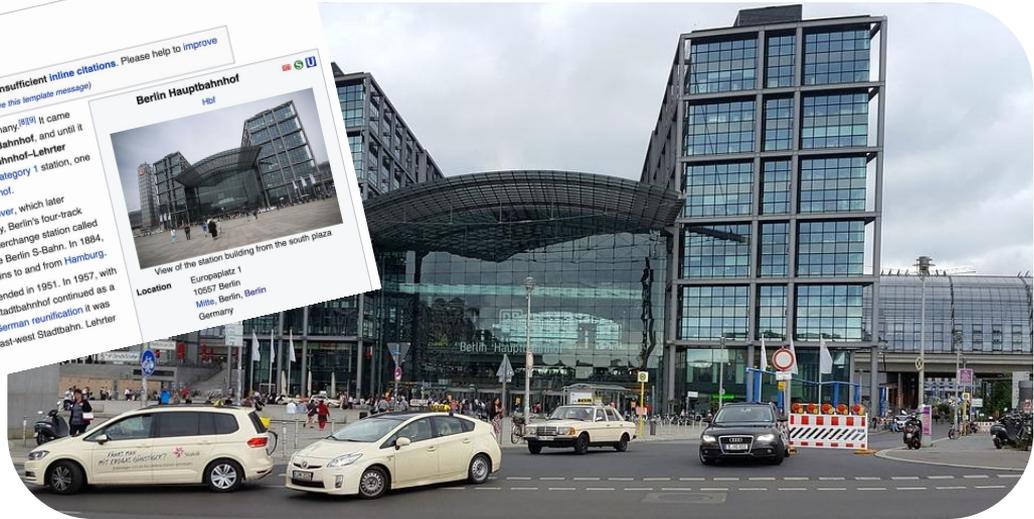
**Berlin Hauptbahnhof** (Main article) (English: **Berlin Central Station**) is the main railway station in Berlin, Germany. It came into full operation two days after a ceremonial opening on 26 May 2006. It is located on the site of the historic **Lehrter Bahnhof**, and until it opened as a main line station, it was a stop on the Berlin S-Bahn suburban railway temporarily named **Berlin Hauptbahnhof-1** station, one of 21 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) interchange station called **Lehrter Stadtbahnhof** was opened to provide connections with the new line. This station later became part of the Berlin S-Bahn. In 1884, after the closure of nearby *Hamburger Bahnhof* (Hamburg Station), Lehrter Bahnhof became the terminus for trains to and from *Hamburg*.

Following heavy damage during *World War II*, limited services to the main station were resumed, but then suspended in 1951. In 1957, with 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.

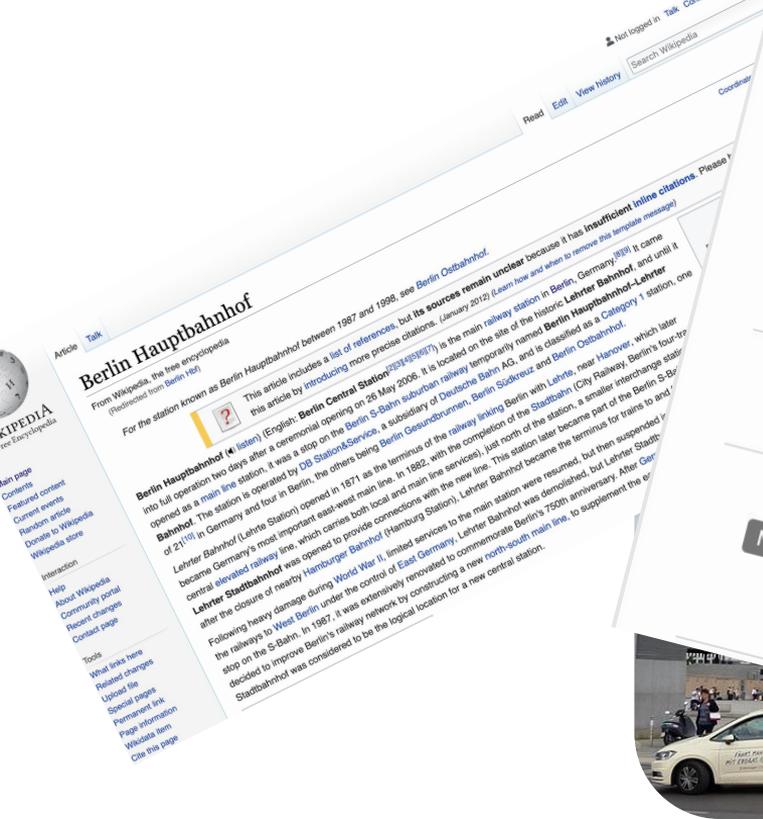
**View of the station building from the south plaza**

<b>Location</b>	Europaplatz 1 10567 Berlin Mitte, Berlin Germany
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Wikipedia

Michael Galkin 7. Leipziger Semantic Web Tag 22.05.2019



Rank	Model	EM	F1
1 Mar 20, 2019	Human Performance Stanford University <i>(Rajpurkar &amp; 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 <a href="https://github.com/google-research/bert">https://github.com/google-research/bert</a>	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
86.673	89.147

N-Gram Masking + Synthetic Self-  
 Training (ensemble)  
 Google AI Language  
<https://github.com/google-research/bert>



# Passage Retrieval(10/26/2018-Present)

Ranking Style	Submission Date	MRR@10 On Eval	MRR@10 On Dev
Full Ranking	May 13th, 2019	0.383	0.397
	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 <sub>1</sub>	EM	F <sub>1</sub>	EM	F <sub>1</sub>
1	Cognitive Graph QA (single model) <i>Tsinghua KEG &amp; Alibaba DAMO Academy</i> <a href="#">Ding et al., ACL19</a>		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

EM	F <sub>1</sub>
86.831	89.45
87.147	89.474
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86.673	89.147

Rank	Model
1	Enriched BERT b
2	Enriched BERT t
3	BERT^2 (1)Roi
4	Enriched BEF
5	BERTter Inc

# 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?



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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?

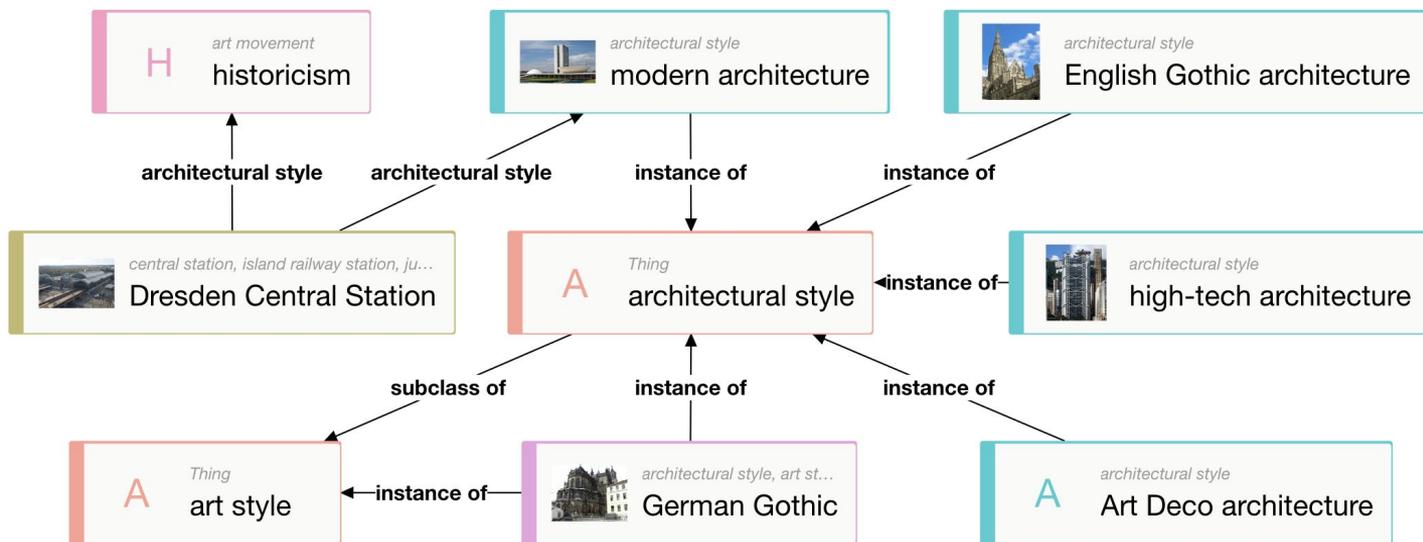


# With KG flavors

Can mushrooms be  
an architectural  
style?

**Probably not**

If not, what can be  
an appropriate  
value?



# 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

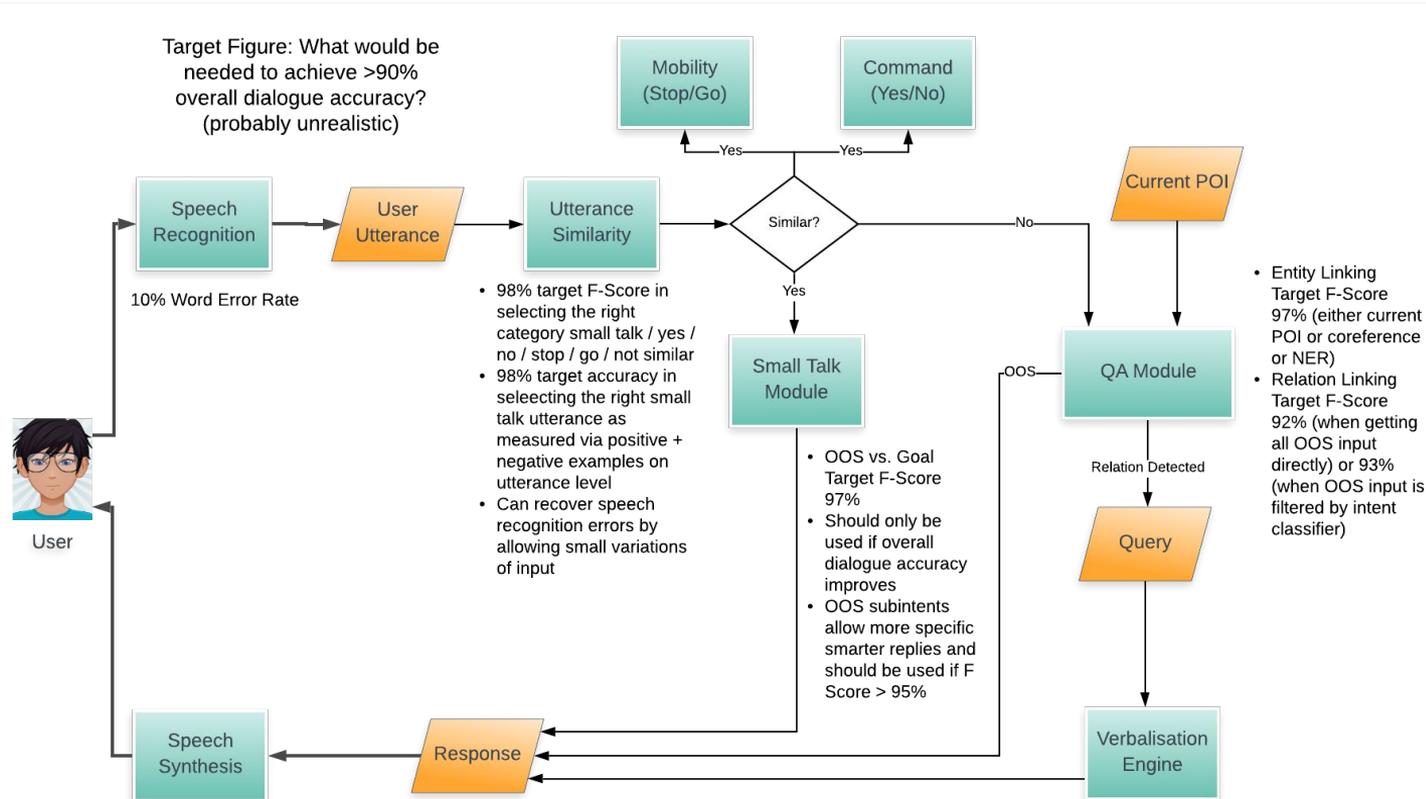
# KDDS

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

Full DBpedia  
2019 (wikidata  
branch)

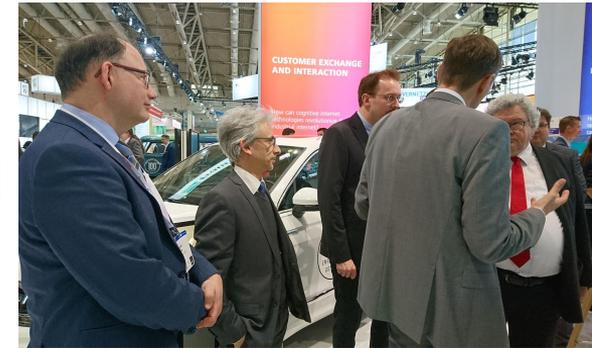
> 50M entities

> 4B triples



# KDDS @ Hannover-Messe

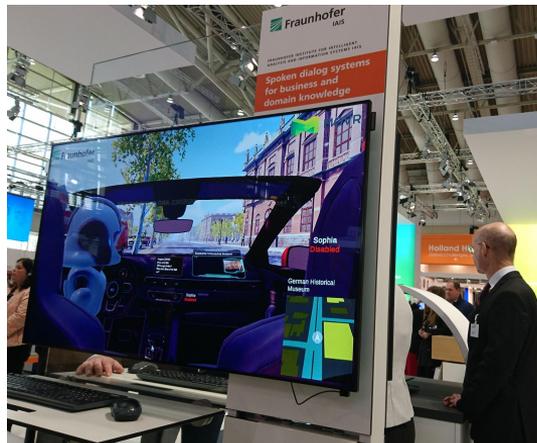
Building KGs from enterprise  
sources is still a challenge



# 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

# Fraunhofer IAIS Dresden

## Center for Efficient and Explainable AI



- Efficient AI
  - Hardware and software are usually decoupled instead of embedded
  - 100-times more energy efficient by 2030
- Explainable AI
  - Make AI more traceable
  - Make AI decisions more explainable



Prof. Lehmann



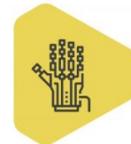
Prof. Fitzek



SUPPORTING AI LIGHTHOUSES



AI APPROACH LIGHTHOUSES



AI APPLICATION LIGHTHOUSES



FOR THE PEOPLE

# Center for Explainable and Efficient AI



## Supporting AI lighthouses

CEE AI can build on strong structures at the TU Dresden campus: advantages can be used from the beginning for big data, microelectronics, connectivity, and cyber-physical systems.

- Efficient
- Connected
- Scalable
- Cooperative



## Lighthouse AI approaches

In CEE AI, we will draw on the expertise of the Next Generation Machine Learning Lab of Technische Universität Dresden and Fraunhofer IAIS as the leading Fraunhofer institute on AI.

- Explainable (XAI)
- Knowledge-driven
- Ground-breaking
- Certified



## Lighthouse AI applications

Fraunhofer institutes in the Dresden region that provide applications for industry as central part of their mission; and TU Dresden reaching out to other organisations and industry.

- Human-centric
- Flexible
- Mobile
- Reliable



## AI for us

CEE AI will detail value and risk of AI for the society and will teach AI concepts for a responsible and informed society by combining excellent research and practical applications.

- Social
- Educated
- Applied
- Excellent