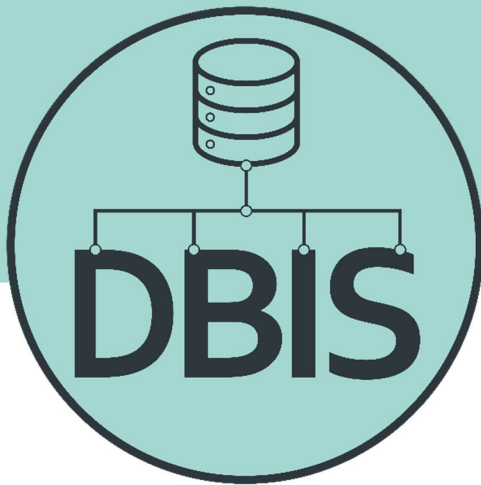




University  
of Basel

# Databases and Information Systems (DBIS) Research Group

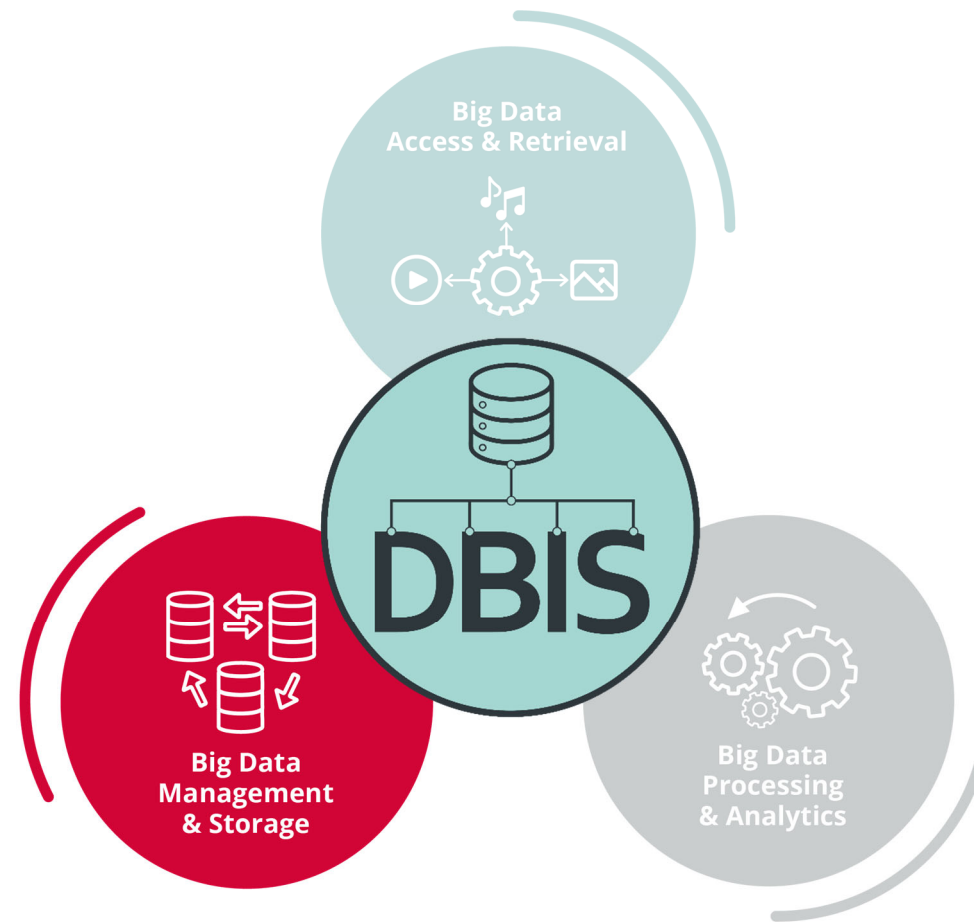
Prof. Dr. Heiko Schuldt



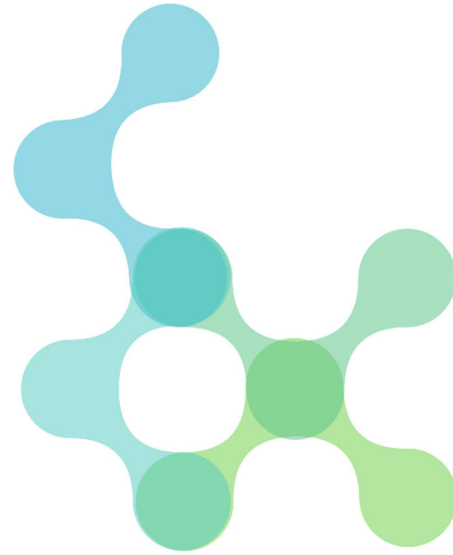
# Databases and Information Systems Research Group



# Databases and Information Systems Research Group



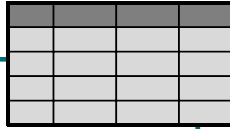
## Multi-Model Data Management with Polypheny



# Polypheny

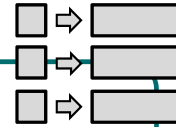
# Data Models: One Size Does *Not* Fit All

## Relational DB



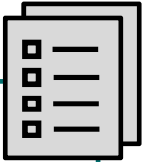
- Table representation
- Structured data in a strict schema
- Transactional workloads

## Key-Value Store



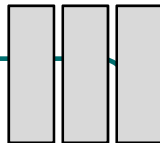
- Array-like data
- High performance and scalability
- Allows storing arbitrary values

## Document Store



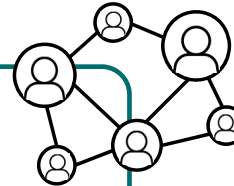
- Collection of documents
- Unstructured data / following no schema
- Nested structures

## Analytical DB



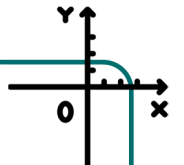
- Comes in various shapes, e.g., based on the relational model
- All items of a column are stored together

## Labeled-Property Graph



- Data is represented using nodes and edges
- Good for storing and querying relationships

## Vector DB



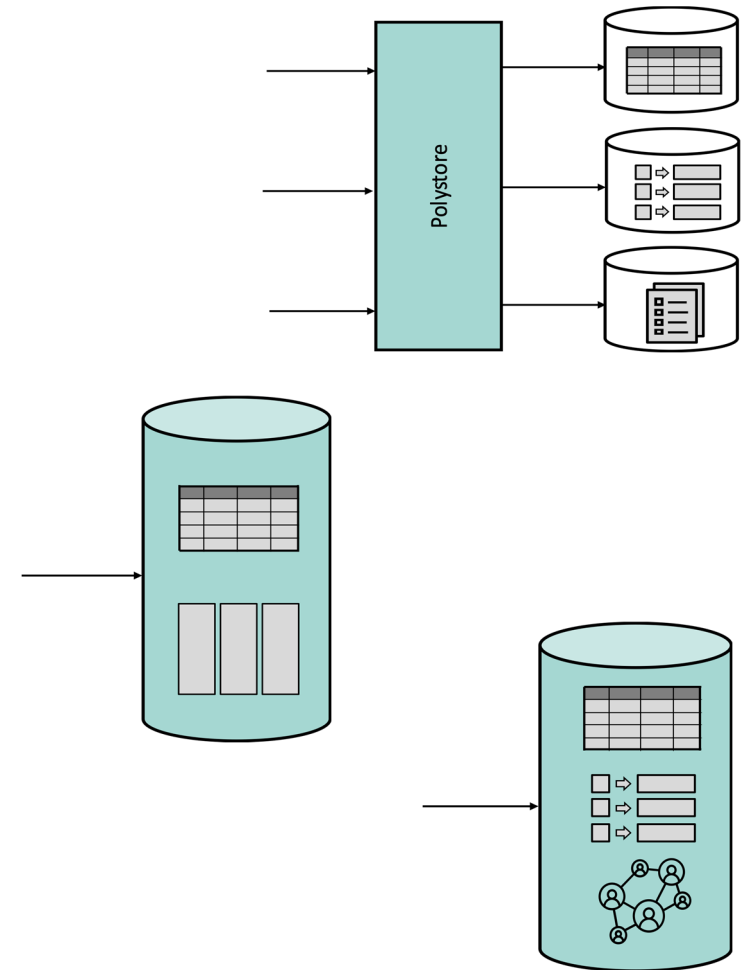
- Collection of high-dimensional vectors
- Similarity search (nearest neighbors)

# PolyDBMS: A New Type of Database System

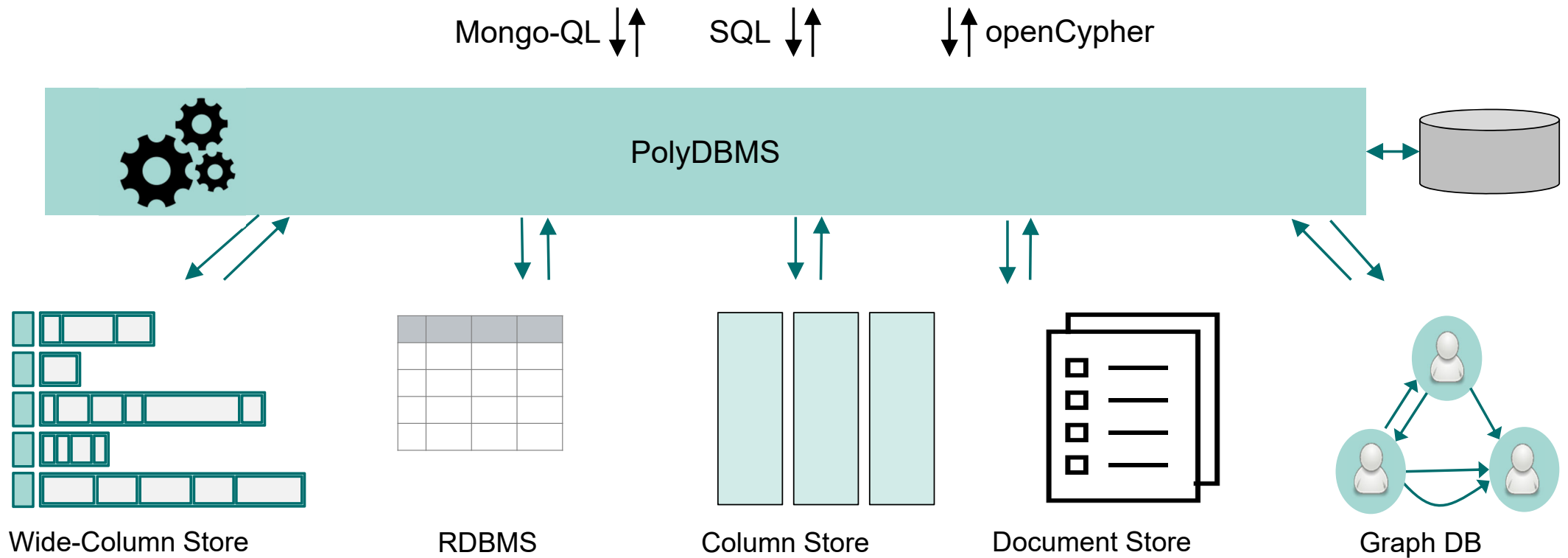
- There is the need for a system that ...
  - maintains data according to **multiple data models**
  - supports **multiple query languages**
  - provides good performance for mixed workloads
  - supports data manipulation queries



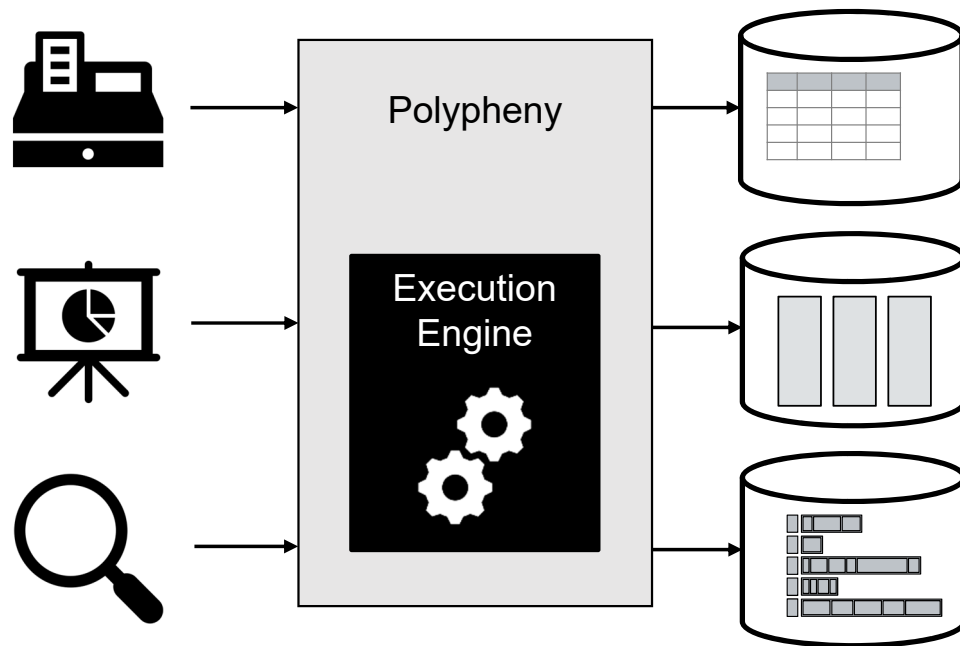
A PolyDBMS combines the concepts of polystores, multimodel database systems and HTAP systems



# PolyDBMS: Logical View



# Our implementation of a PolyDBMS: Polypheny

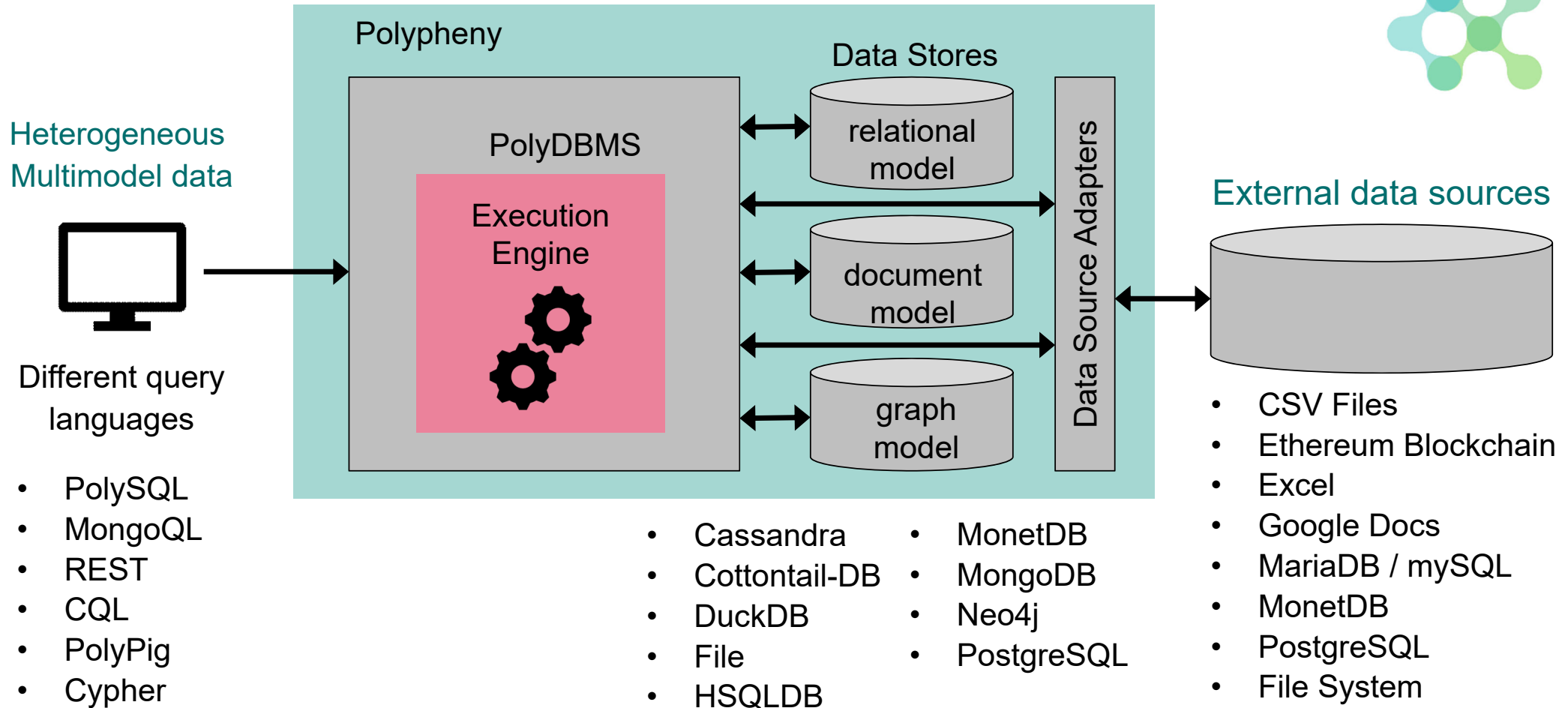


Polypheny is a full-fledged database system that ...

- ... uses existing database systems as storage and execution engines
- ... has an integrated execution engine to compensate missing features and processes joins
- ... supports cross-model queries and replication
- ... enforces constraints across stores
- ... utilizes the optimization and domain-knowledge of specialized systems
- ... supports different workloads (OLTP, OLAP)



# Polypheny in Detail



# Polypheny in Practice

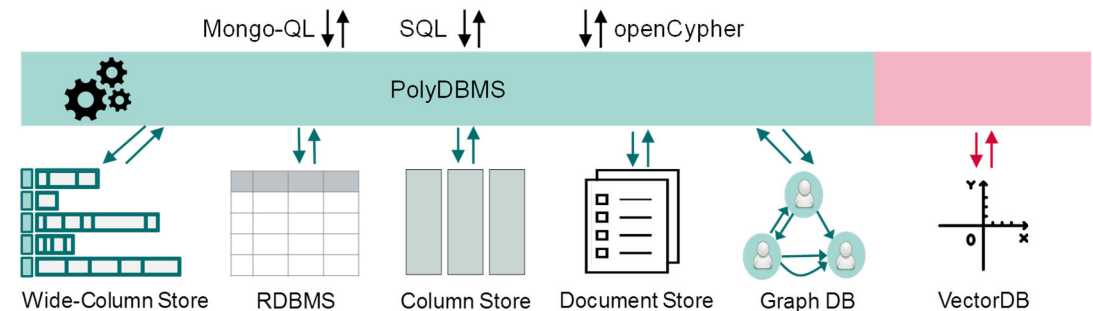
- Open Source (Apache 2 License) Community Edition
- Commercial system  
polypheny.org | @polypheny
- Google Summer of Code 2021, 2022, and 2024

A screenshot of the Polypheny web application interface. The interface is dark-themed and includes a navigation menu on the left with options like 'console', 'Execution time', 'Generated Code', 'Query analysis', 'Routing', and 'PLANS'. The main area shows a SQL query editor with the text 'select \* from emp'. Below the editor, there are checkboxes for 'analyze query', 'use cache', and 'save in history', along with a 'SQL' dropdown and an 'Execute' button. The results are displayed in a table with columns: empid, deptno, name, salary, and commission. A 'History' panel on the right shows a list of executed queries with timestamps and SQL snippets.

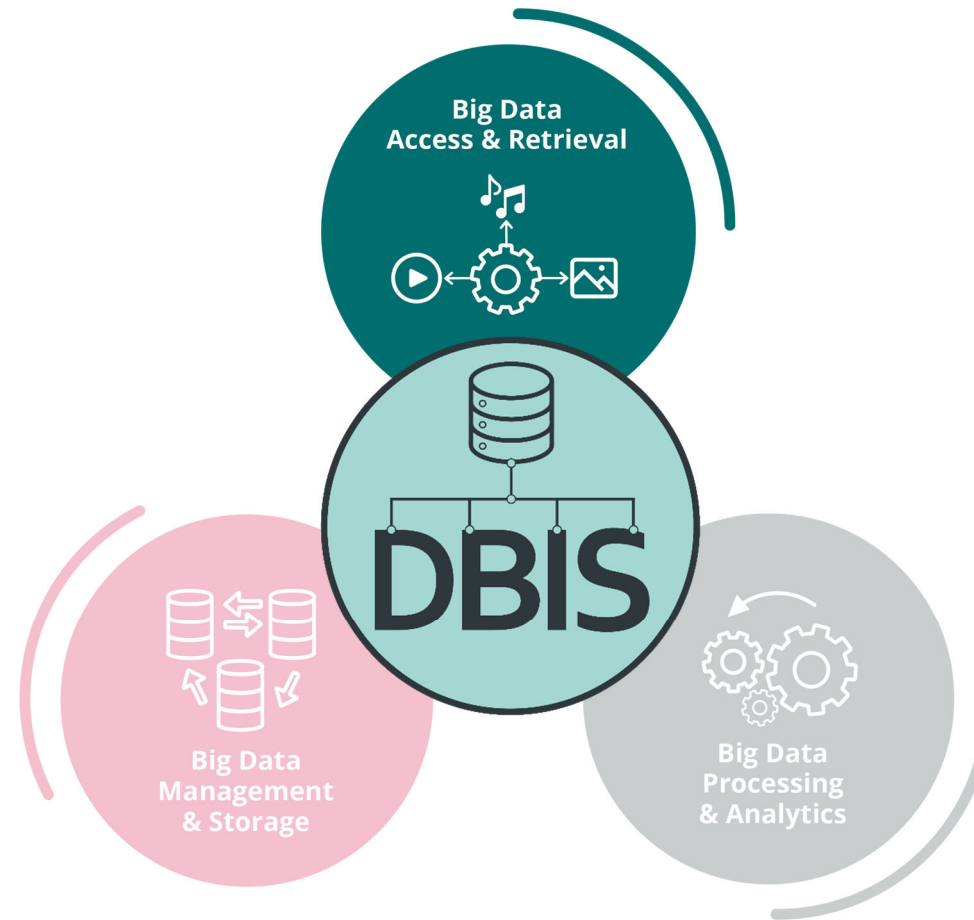
empid	deptno	name	salary	commission
100	10	Bill	10000	1000
110	10	Theodore	11500	250
150	20	Sebastian	7000	400
200	30	Eric	8000	500

# Polypheny: Potential Topics

- Multi-model data streaming
- Temporal and multi-version data management
- Cross-model integrity constraint enforcement
- Multi-model query optimization
- Management and visualization of spatial data
- Connectors / drivers for different languages (e.g., Go, PHP, C++, C#, )
- Integration of vector DBs as data stores / data sources
- Integration of additional data sources
- UI for a Polystore (Angular)
- ... and others



# Databases and Information Systems Research Group



# Multimedia Search with vitriiv

# Searching in Big Multimedia Data (Today)

- Keyword Search: Search based on (manually added) textual descriptions
- Query-by-Example: Similarity to query object (e.g., Google Image Search)

Image sources:

<https://x.com/Greenpeace/status/316866068368986112>

<https://www.flickr.com/photos/thebigwrench12/773973981>

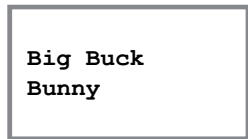
<https://www.pexels.com/photo/close-up-of-polish-hen-16776579/>

<https://unsplash.com/de/s/fotos/Polnisches-Hiuhn>

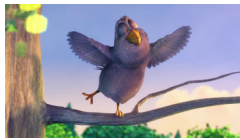
<https://www.pinterest.com/pin/striking-bufflaced-polish-rooster-definitely-a-chicken-demanding-notice-200269514666252676/>



# Query Modes in vitrivr



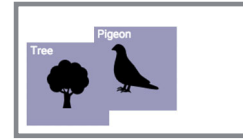
**Query-by-Text:**  
keyword search  
(text, subtitle, ...)



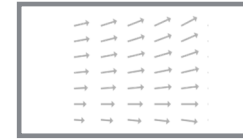
**Query-by-Example:**  
Search with  
sample object



**Query-by-Sketch:**  
Search with  
hand-drawn  
sketch



**Query-by-Object:**  
Search for  
semantic  
concept



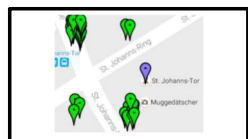
**Query-by-Motion:**  
Search for  
specific  
motion



**Query-by-Audio:**  
Search for  
audio  
similarity



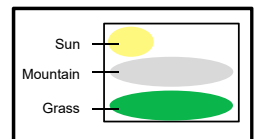
**Query-by-Time**  
When has an object  
been created?



**Query-by-Location**  
Where has an object  
been created?



**Query-by-SemanticSketch**  
concepts & spatial  
relationship



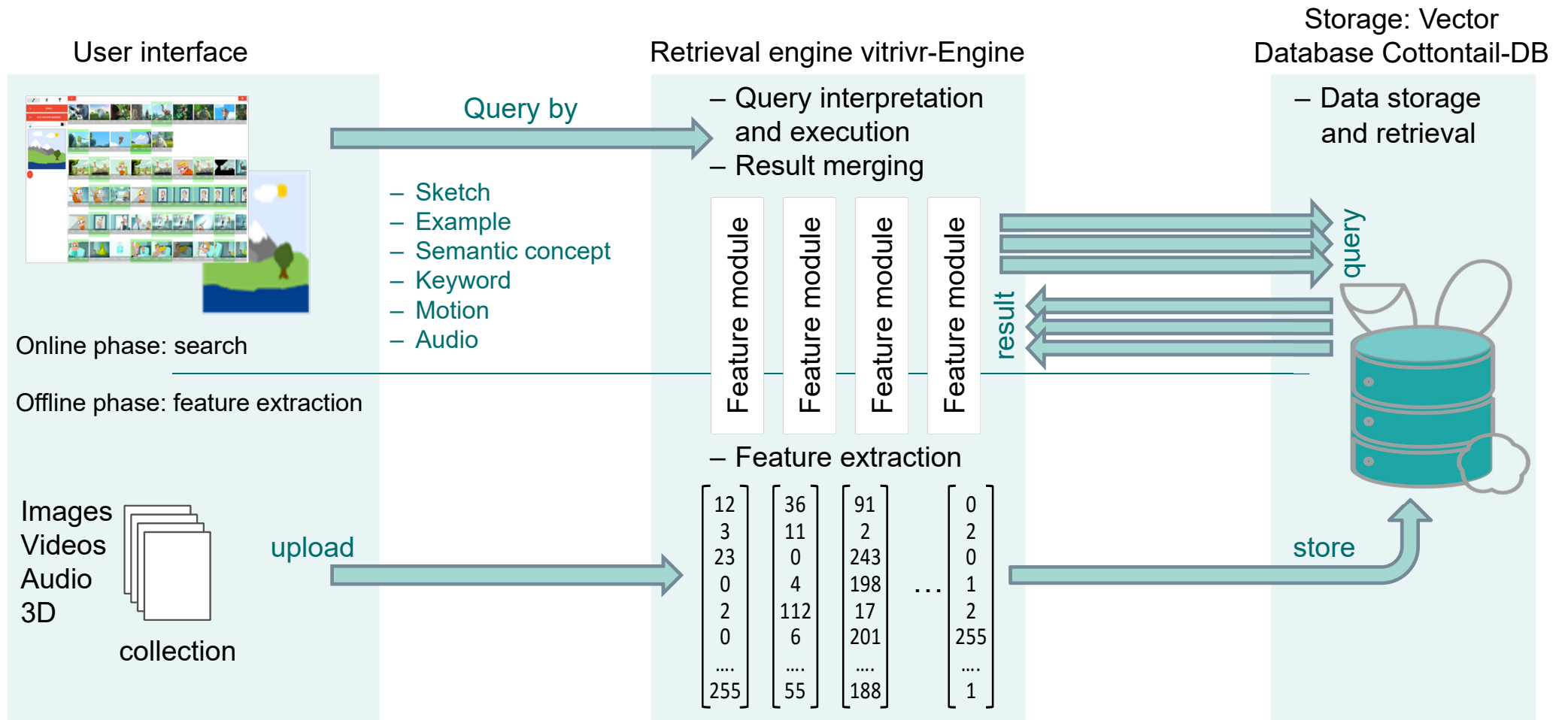
**Query-by-Pose/  
Gesture** Similar body  
pose/hand gesture?



+ -

**Relevance Feedback: Refinement of Search Results**

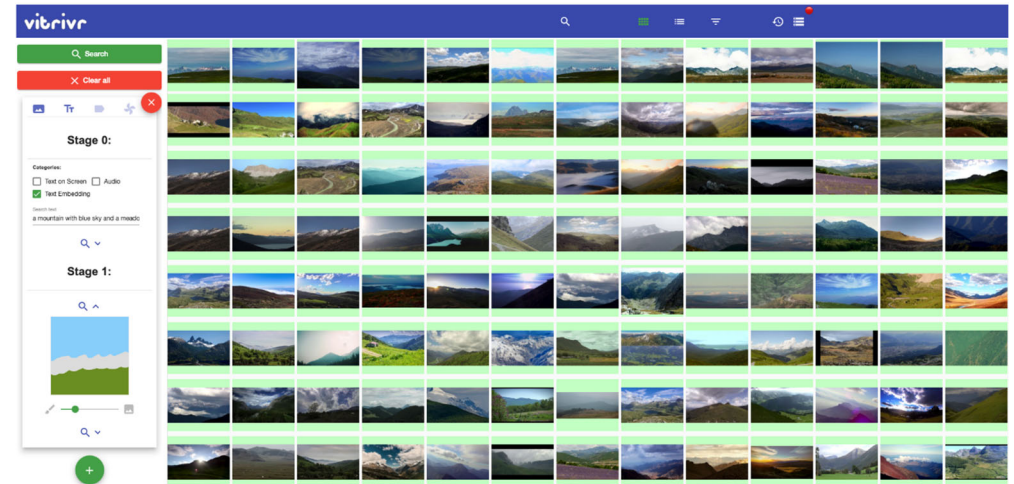
# vitivr: From the Query to the Result



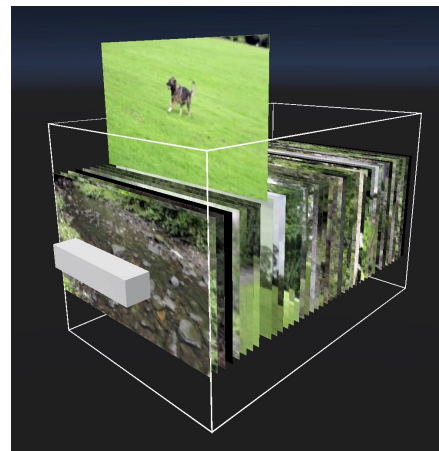
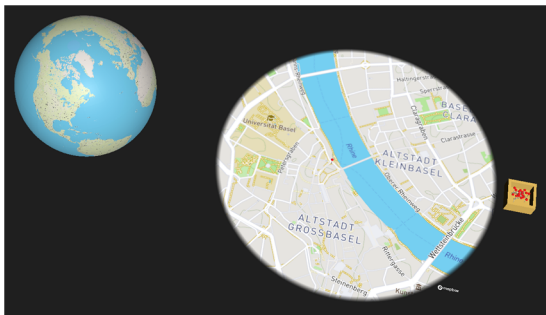


# vitrivr: User Interfaces

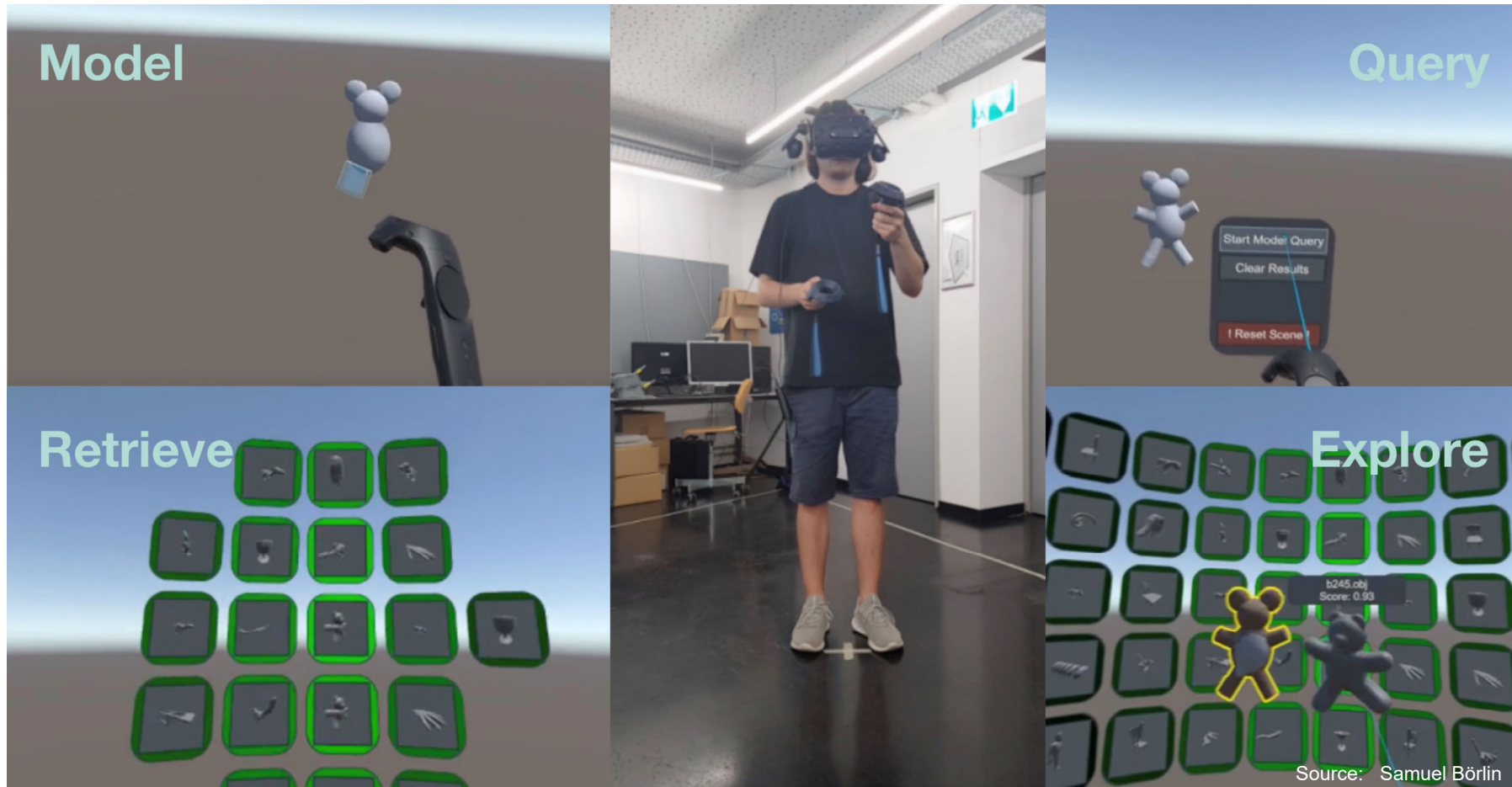
- Traditional 2D desktop UI:



- Virtual Reality Interface



# vitriivr-VR: Search in 3D Collections



# Applications – GoFind!

- vitrivr front-end for smartphones
- Focus: cultural (architectural) heritage
- Collaborations with the University Library and Lost Basel

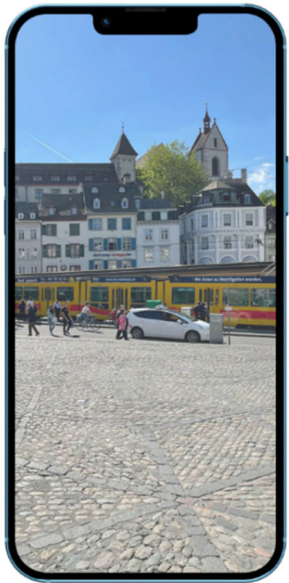
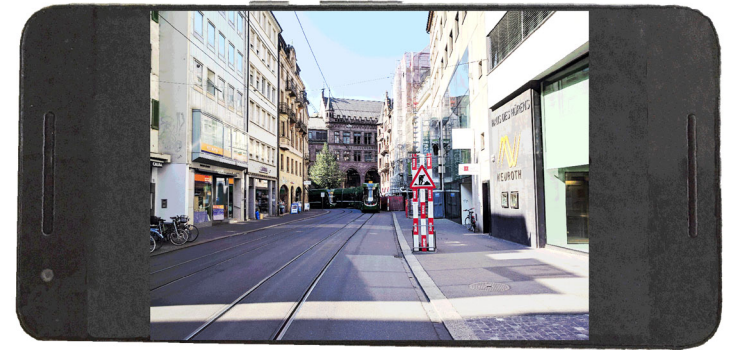


Image source: Adobe Stock 590438597 /  
Verschwundenes Basel / ETH Bibliothek



# Applications: XReco



- Content-based search in Mixed Reality (2D and 3D)
  - Query: live recognition of objects
  - Results: seamlessly embedded into current scene



Original



Source: Victory Rain

Object  
recognition

Object selection



Similarity  
search

Positioning of results



# Multimedia Search Applications: Sport Data

Sport Sense

Events

- Goals
- Shots on target
- Shots off target
- Passes
- Passes - Ball recovery
- Passes - Ball touch
- Passes - Offside
- Clearance
- Interception
- Take on
- Tackle
- Corner Kicks
- Foul

Team: Bolton

Player: --Any--

Period: 1

Total matching segments: 2 - Elapsed: 1.33 s

Clear Refresh

Event	Period	Time	Duration (s)
Segment 1	1	10:25	44
Segment 2	1	17:23	14

Filters

- No event filter selected
- No team filter selected
- No player filter selected
- No period filter selected

Search results

#	Event	Period	Time
1	Event Cascade	-	00:38
2	Event Cascade	-	00:27

# VIRTUE: Interaction in Virtual Reality



- VIRTUE: 'Walking Around The Globe': prototype for virtual reality art exhibitions
- Currently being extended towards as a front-end for vitrivr to explore novel ways of querying and result exploration
- Has been shown several times at the Museum Night in Basel and Bern



# vitivr in Practice

- Academic prototype
- Open Source
- Commercial system with industry partner (4eyes, Basel)

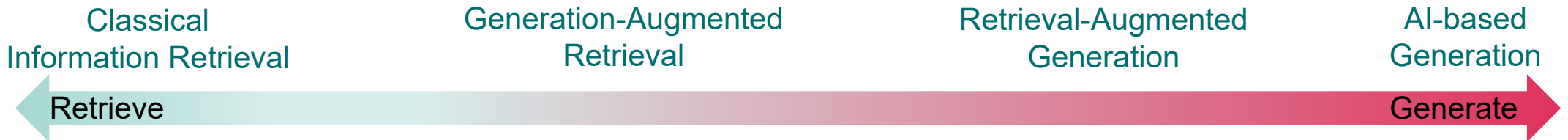
vitivr.org | @vitivr\_org

- Three times at Google Summer of Code

The logo for vitivr, featuring the word "vitivr" in a lowercase, rounded, sans-serif font. The letters are white with a thin black outline, giving it a clean, modern appearance.

## vitivr: Potential Topics

- vitivr backend – CottontailDB: support for novel index types
- vitivr search engine – vitivr-engine: temporal search, advanced search features
  - Face detection and facial expression-based retrieval
  - Explainable multimedia retrieval
  - Explore complete spectrum from retrieval to generation
- vitivr-VR: result presentation and relevance feedback in Virtual Reality
- GoFind!: AR and VR interfaces on mobile devices (“Uni Basel history app”)
- VIRTUE: dynamic creation of museum collections based on user profiles
- Mixed Reality: spatial anchoring of objects
- ... and others





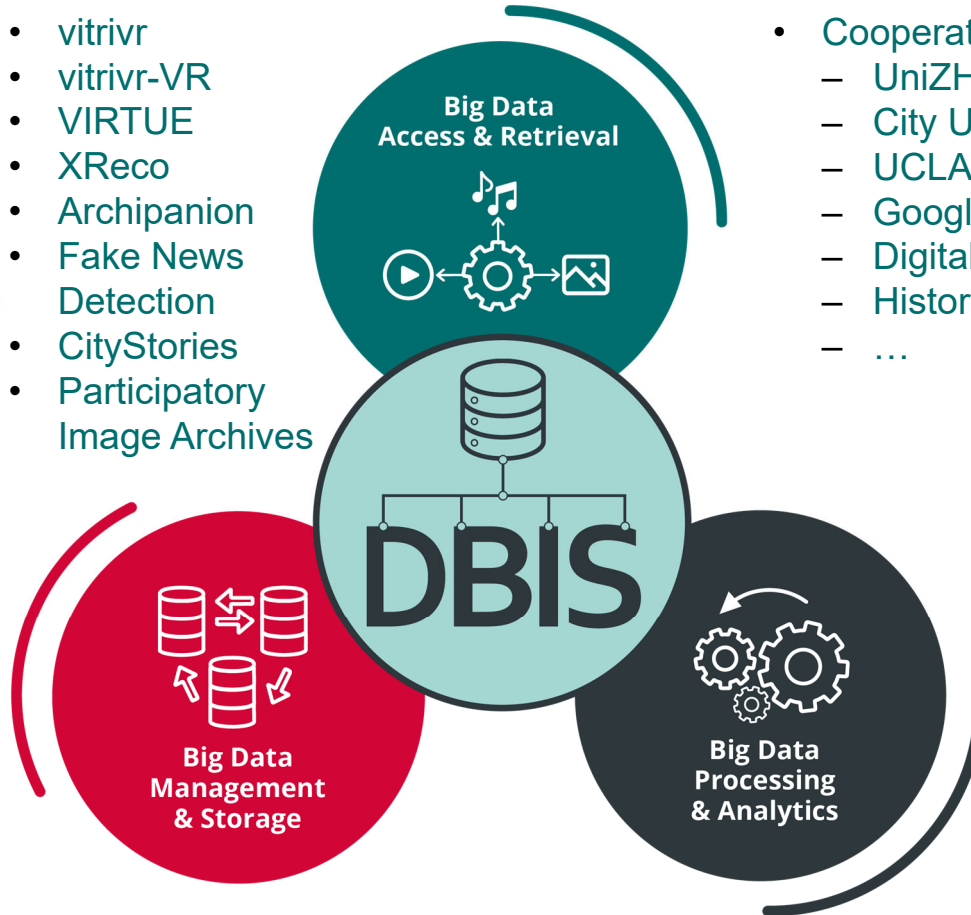
# Databases and Information Systems Research Group



- Polypheny-DB
- Polypheny-DDI
- SwissRenov
- Cooperation
  - GSoC



- vitriv
- vitriv-VR
- VIRTUE
- XReco
- Archipanion
- Fake News Detection
- CityStories
- Participatory Image Archives



- Cooperation
  - UniZH, UniFR, HES-SO
  - City Univ. Dublin
  - UCLA, Case Western
  - Google (GSoC)
  - Digital Humanities
  - Historical Museum BS
  - ...



- StreamTeam
- SportSense
- Cooperation: BASPO

HASLERSTIFTUNG

## Additional Topics ...

- Collaboration with the University Hospital Basel
  - Open-source Electronic Data Capture System



## ... Additional Topics

- Our new member at the DMI: TIAGo (topics in collaboration with other research groups)
  - Add conversational interfaces
  - Make it fit to host events (Fantasy, Info Day, etc.)
  - ... and whatever you could think of





Universität  
Basel

**Thank you for your attention!**

contact: [dbis-cs@unibas.ch](mailto:dbis-cs@unibas.ch)

