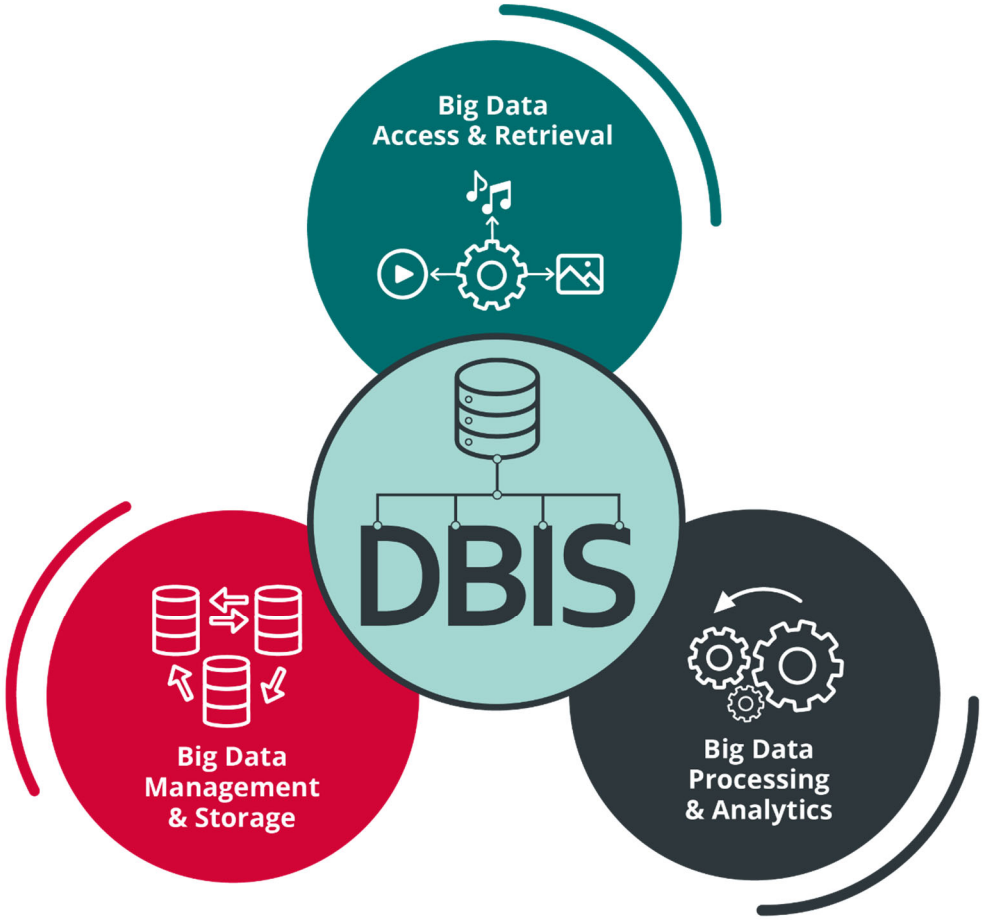
University of Basel

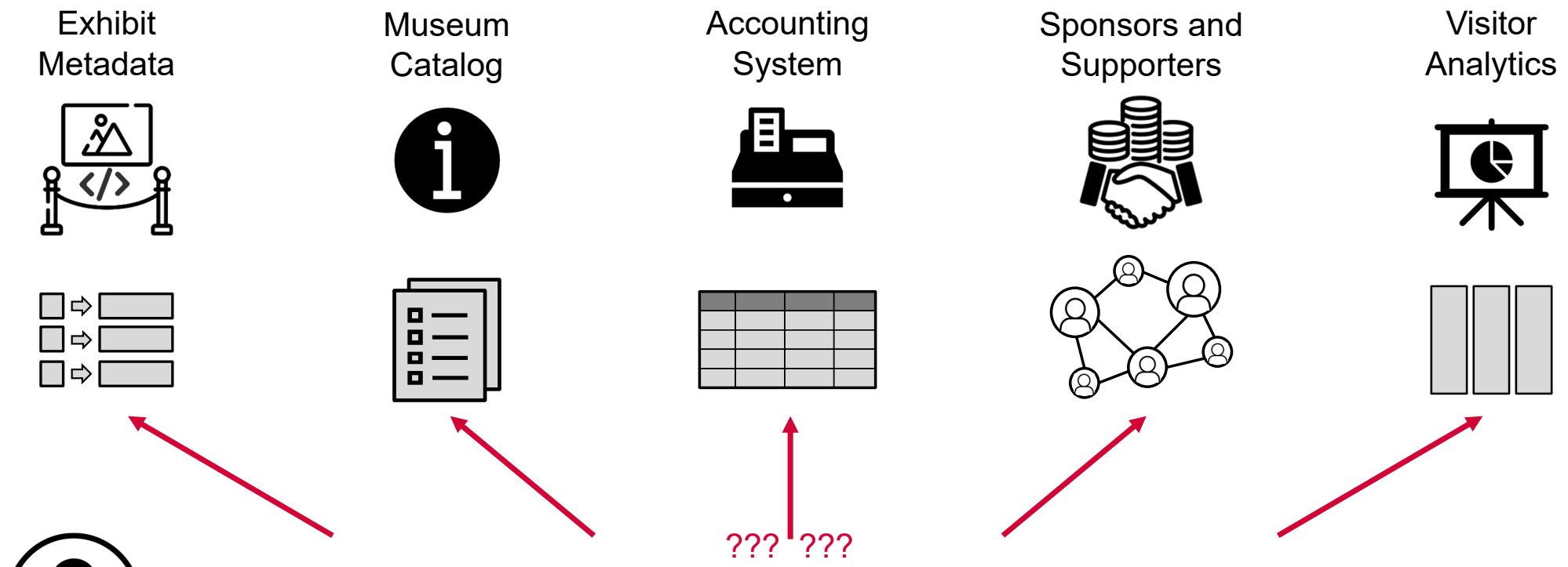
Databases and Information Systems (DBIS) Research Group

Prof. Dr. Heiko Schuldt

Databases and Information Systems Research Group



Example: The Data Management Landscape of a Museum



Query: Show me the rental costs of all paintings that were shown in our most popular special exhibitions which were supported by one of our 'gold' sponsors as patron since 2015.

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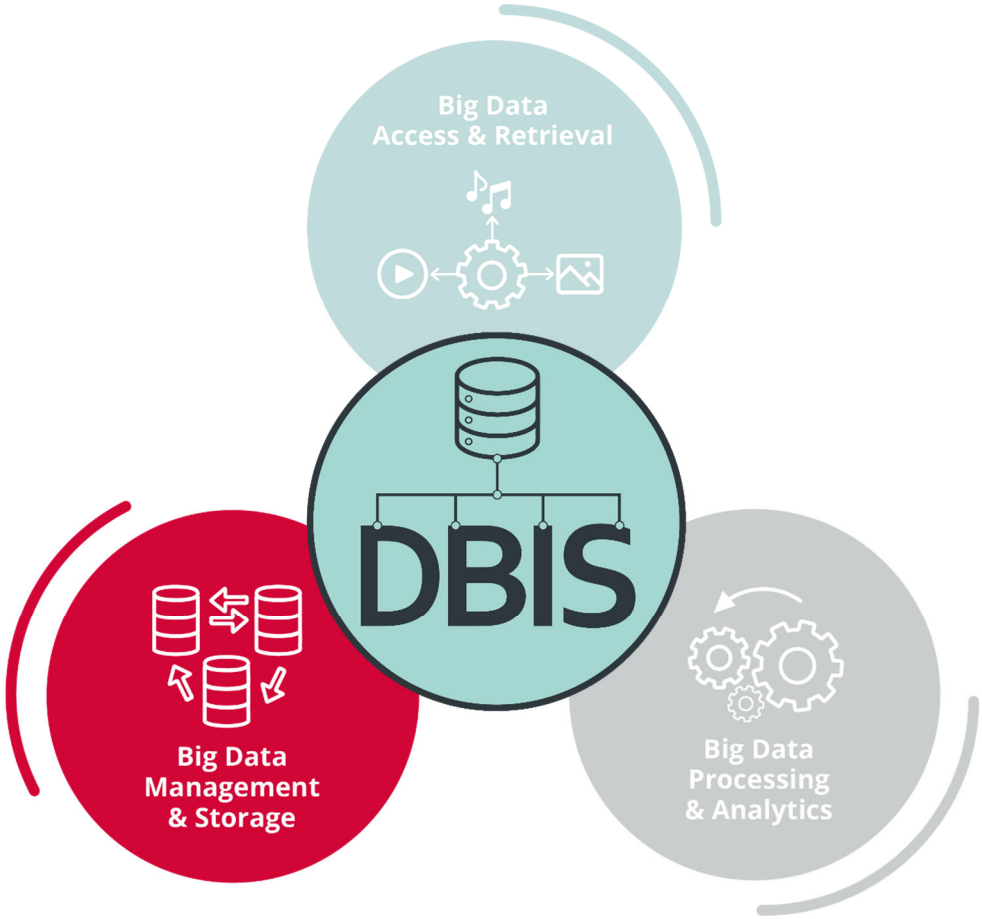
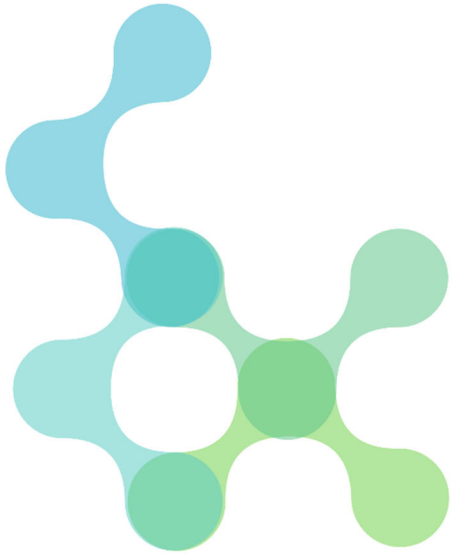
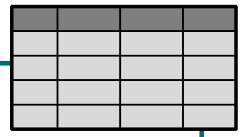


Multi-Model Data Management with Polypheny



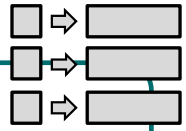
Polypheny

Data Models: One Size Does *Not* Fit All



Relational DB

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

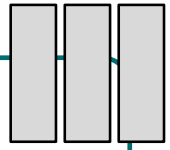


Key-Value Store

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

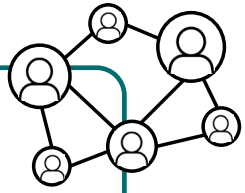
Document Store

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



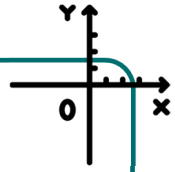
Analytical DB

- 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

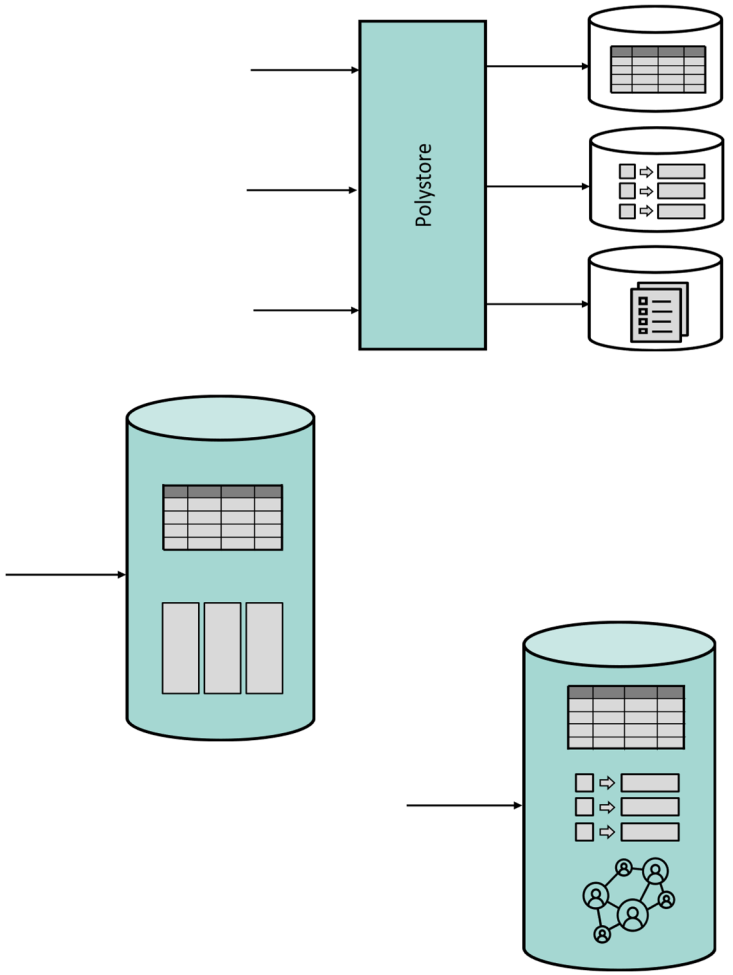


Vector DB

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

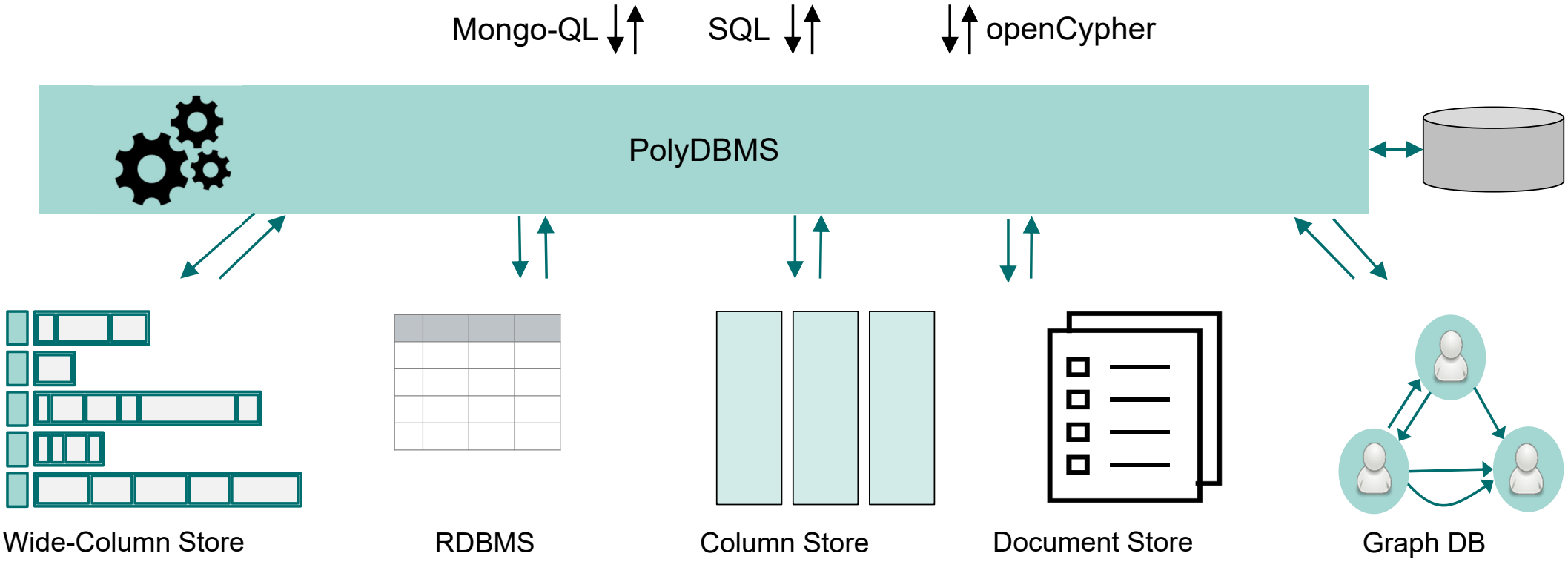
PolyDBMS: A New Type of Database System

- 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

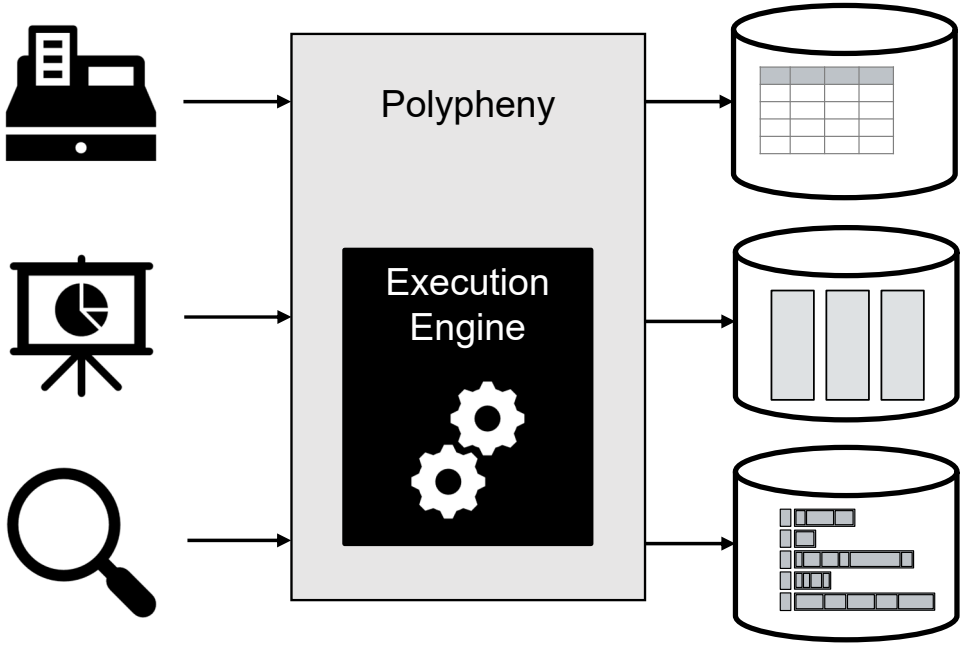


A PolyDBMS provides all these features.

PolyDBMS: Logical View



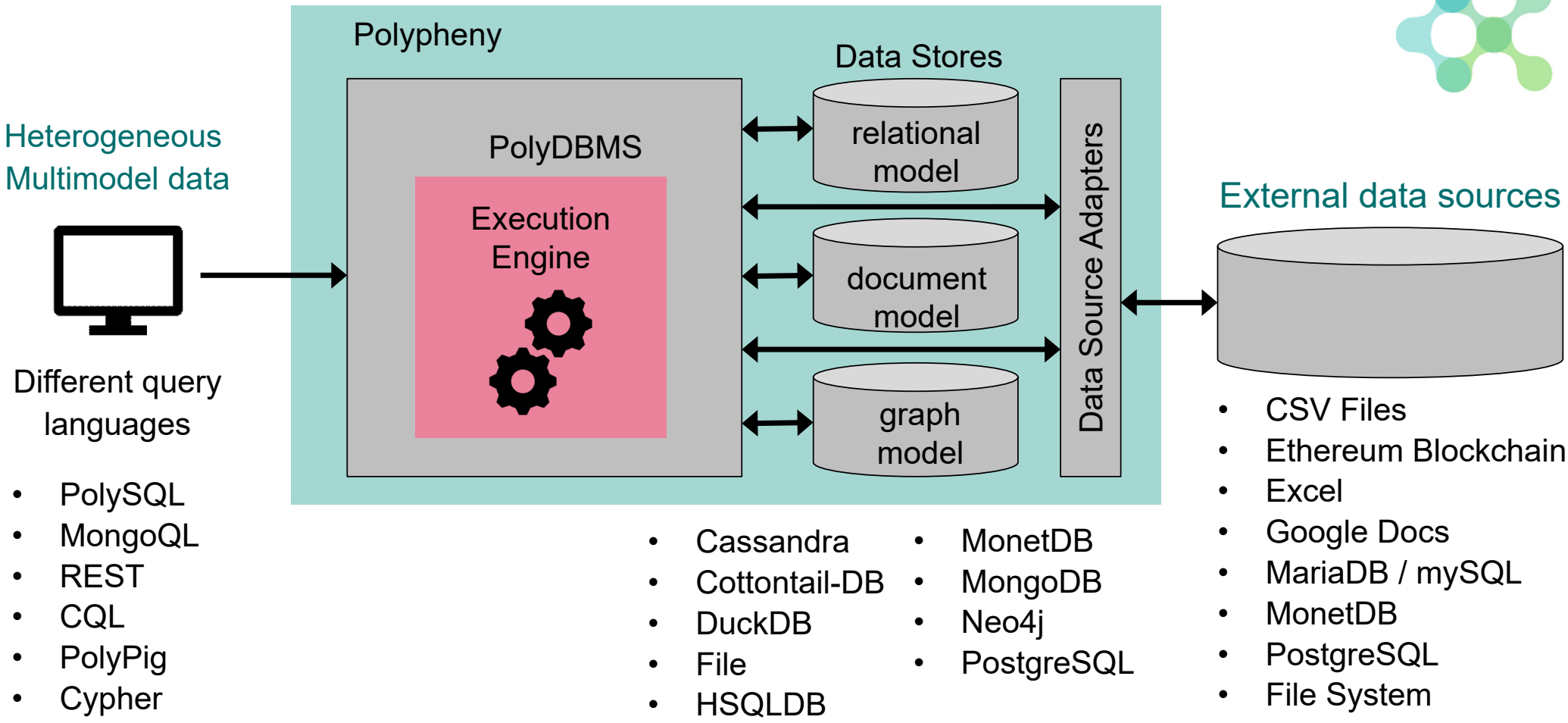
Our implementation of a PolyDBMS: Polypheny



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



- PolySQL
- MongoQL
- REST
- CQL
- PolyPig
- Cypher

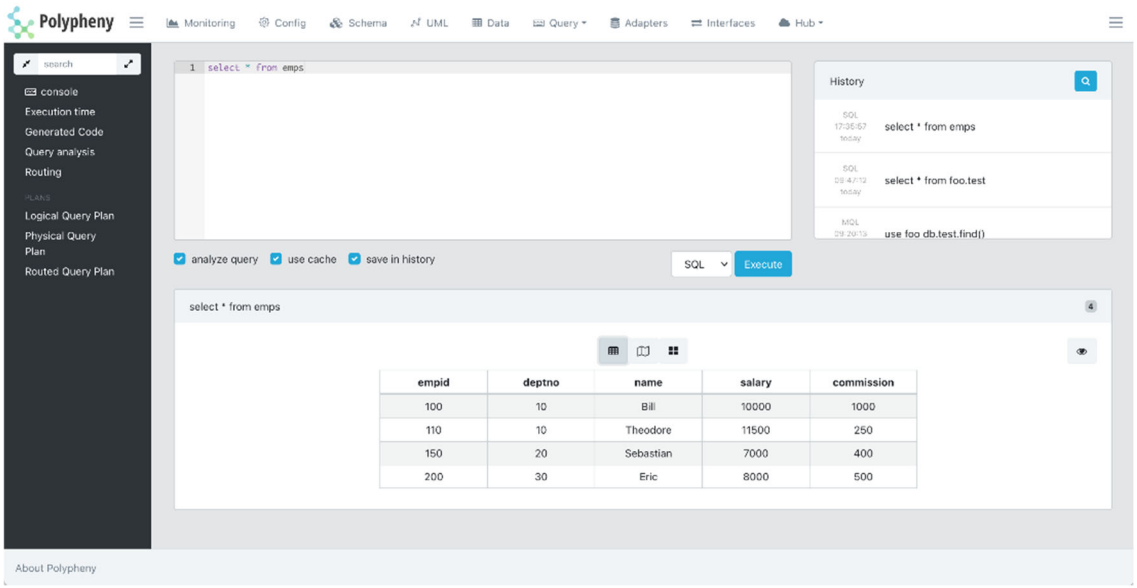
- Cassandra
- Cottontail-DB
- DuckDB
- File
- HSQLDB
- MonetDB
- MongoDB
- Neo4j
- PostgreSQL

- CSV Files
- Ethereum Blockchain
- Excel
- Google Docs
- MariaDB / mySQL
- MonetDB
- PostgreSQL
- File System

Polypheny in Practice

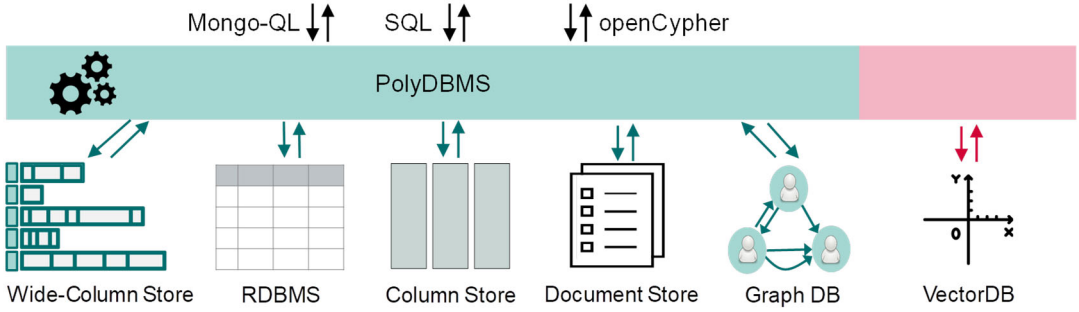
- Open Source (Apache 2 License) Community Edition
- Commercial system
  polypheny.org | @polypheny
- Google Summer of Code 2021, 2022, and 2024

Polypheny

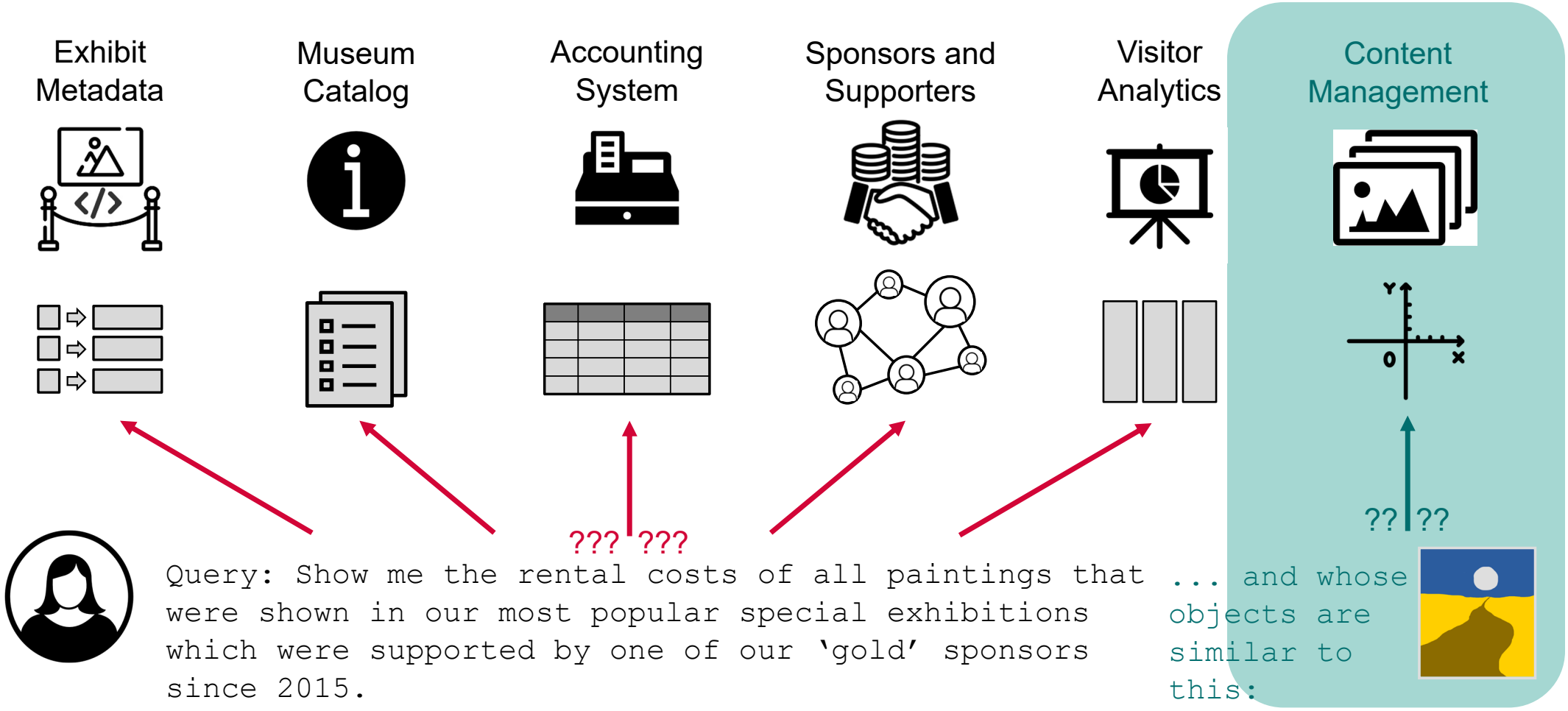


Polypheny: Potential Topics

- 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



Example (continued): The Data Management Landscape of a Museum



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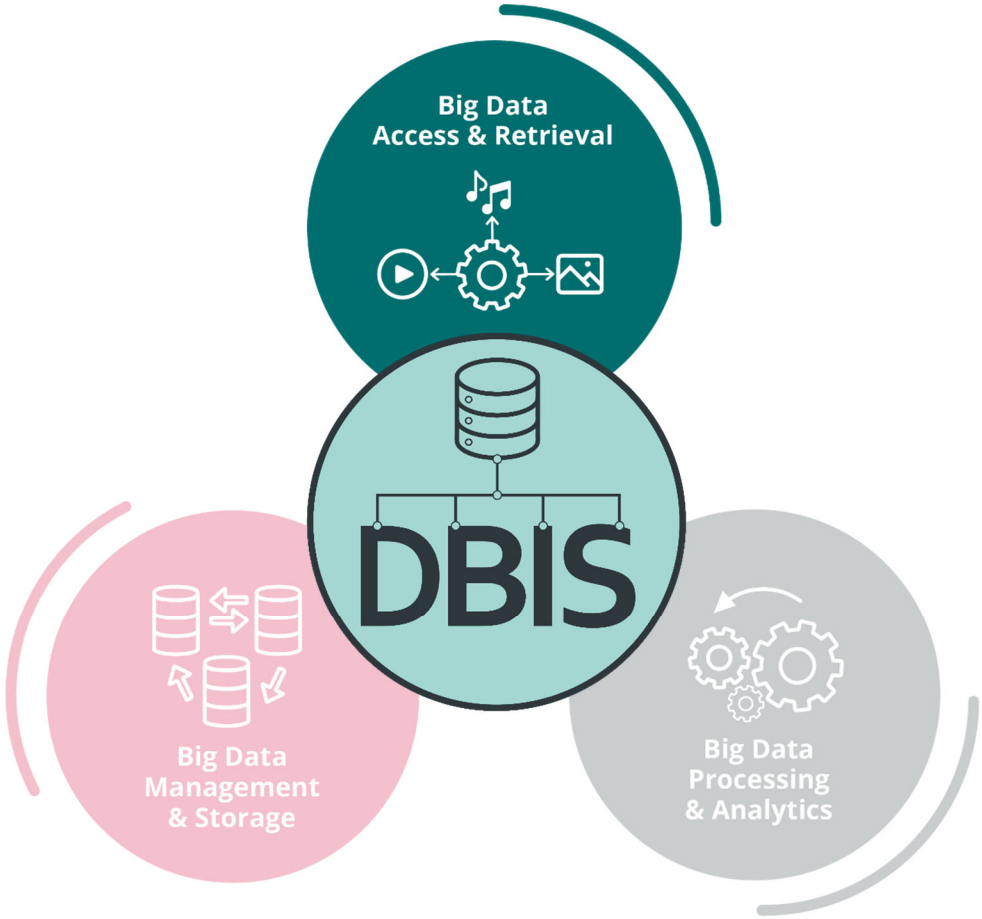
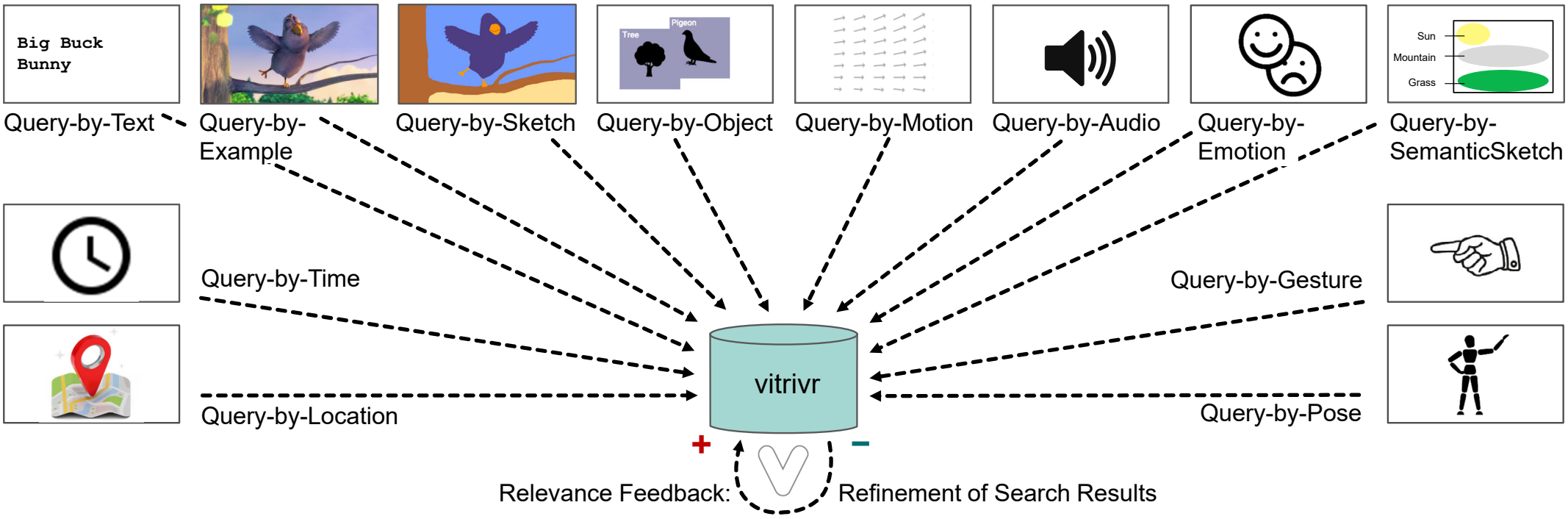


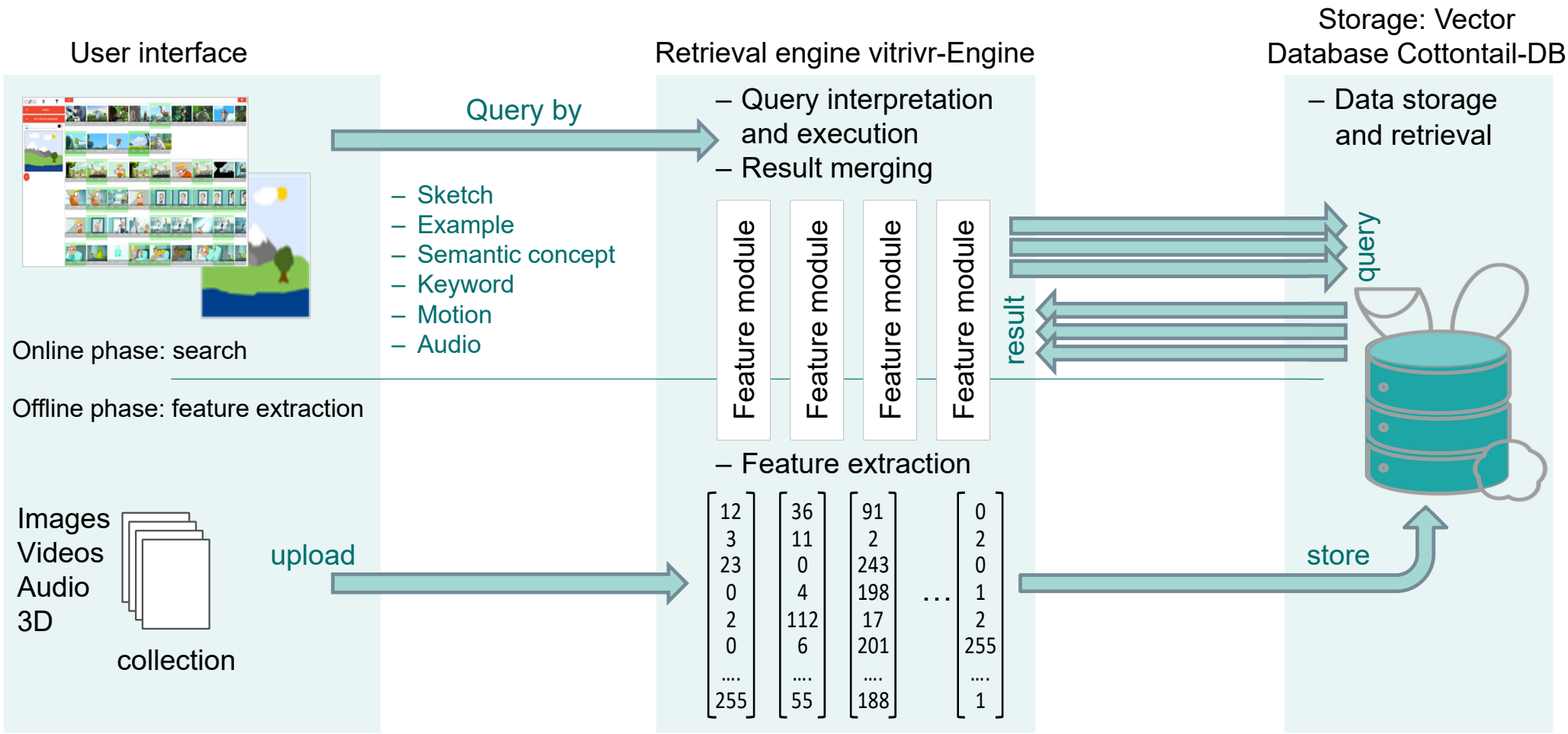
Universität Basel

Multimedia Search with vitrivr

Query Modes in vitrivr

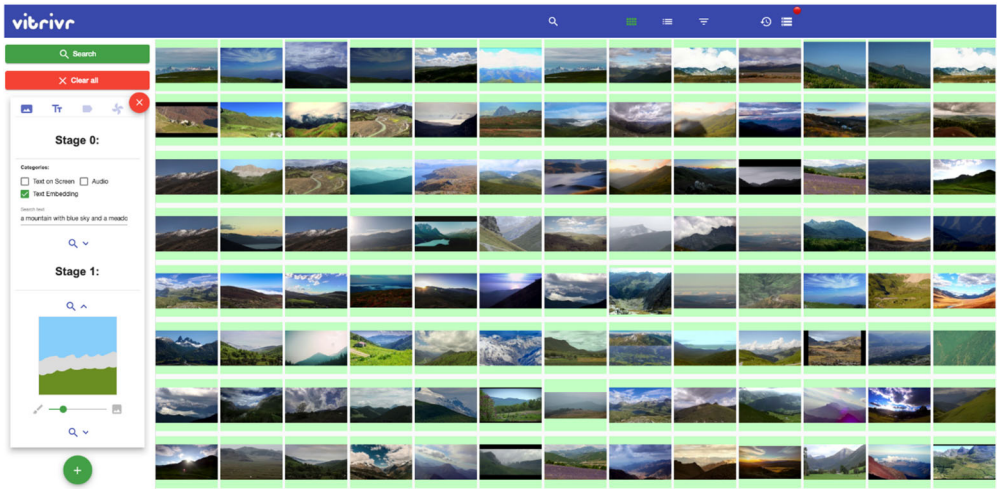


vitrivr: From the Query to the Result

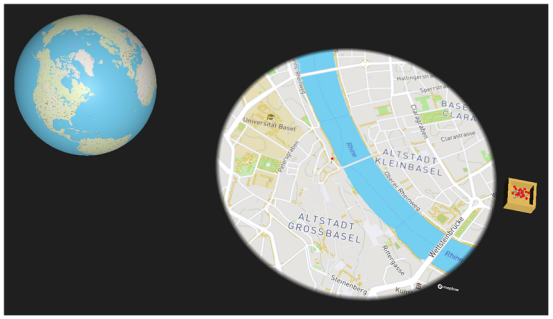


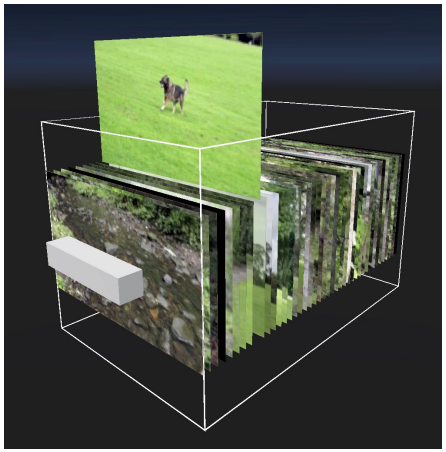
vitrivr: User Interfaces

- Traditional 2D desktop UI:

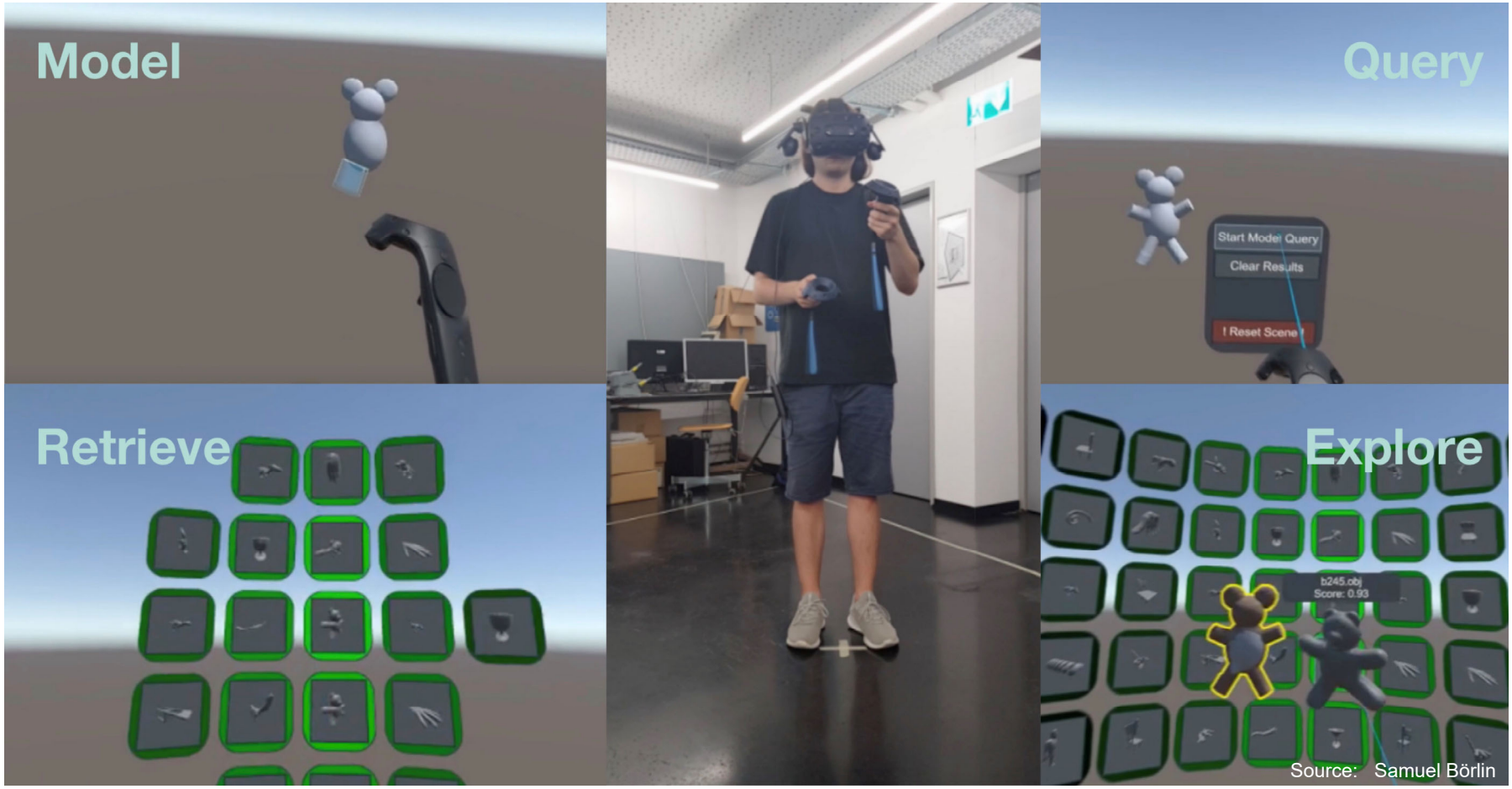


- Virtual Reality Interface





vitrivr-VR: Search in 3D Collections



Applications – GoFind!

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

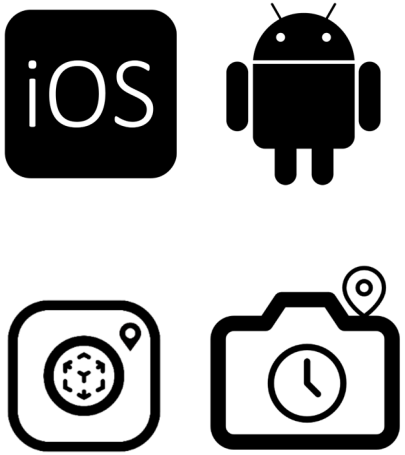
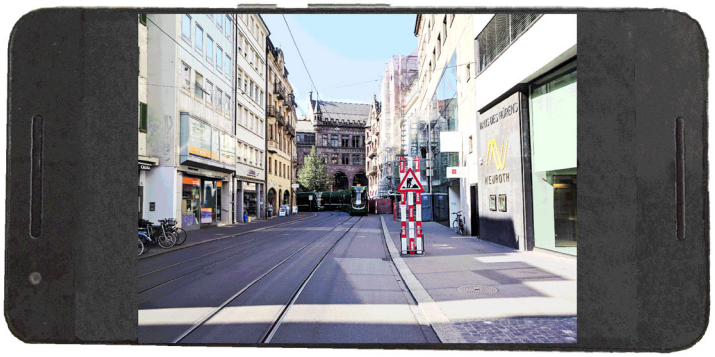


Image source: Adobe Stock 590438597 /

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

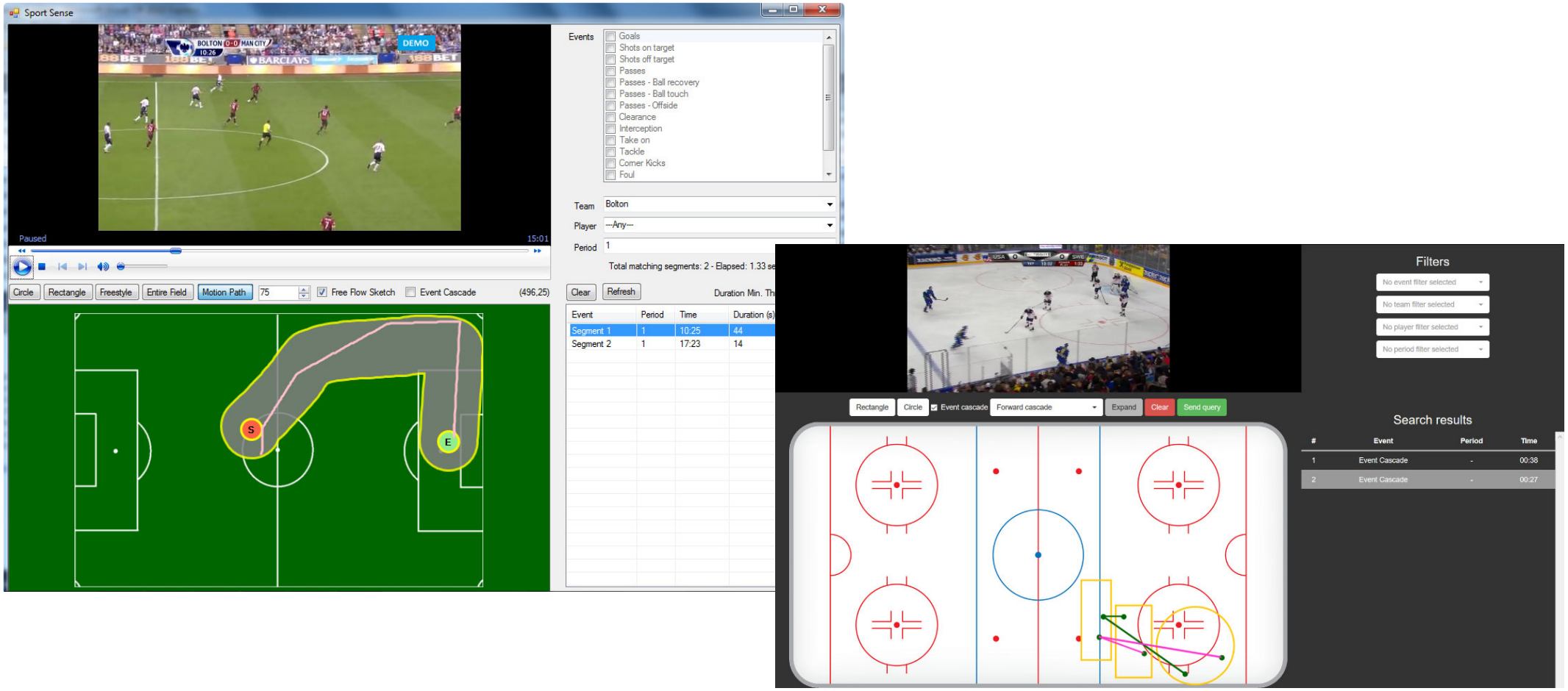
Object recognition

Object selection

Similarity search

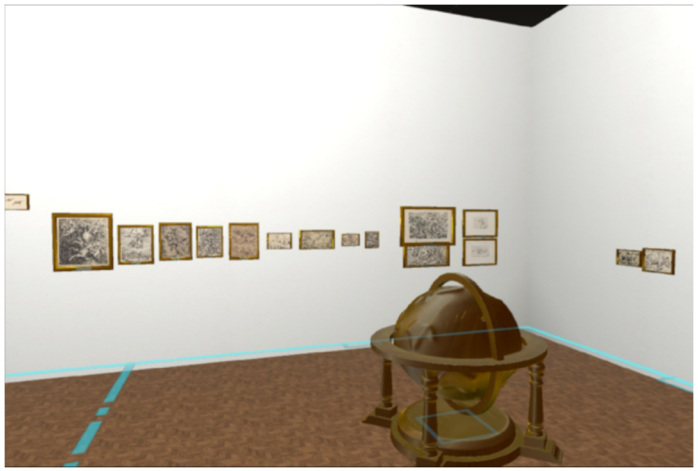
Positioning of results

Multimedia Search Applications: Sport Data



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



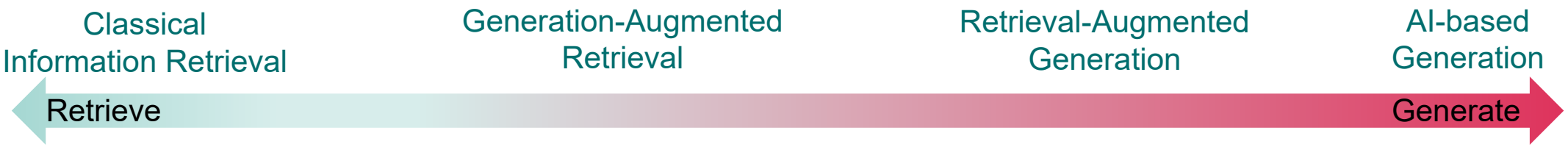
vitrivr in Practice

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

  vitrivr.org | @vitrivr_org
- Three times at Google Summer of Code

vitrivr: Potential Topics

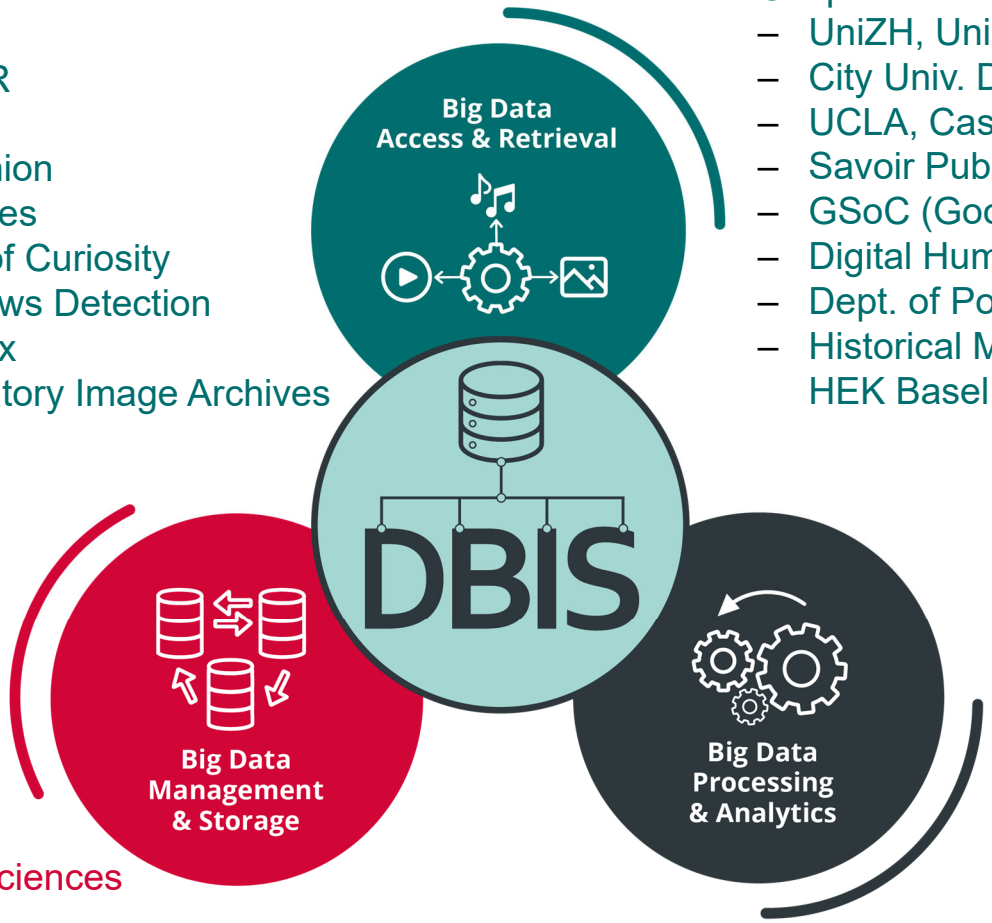
- vitrivr backend – CottontailDB: support for novel index types
- vitrivr search engine – vitrivr-engine: temporal search, advanced search features
  - Explainable multimedia retrieval
  - Explore complete spectrum from retrieval to generation
- vitrivr-VR: result presentation and relevance feedback in Virtual Reality
- Archaeological Object Detection and Segmentation for Mixed Reality Retrieval
- 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: Overview

- vitrivr
- vitrivr-VR
- VIRTUE
- Archipanion
- CityStories
- Engine of Curiosity
- Fake News Detection
- MediaMix
- Participatory Image Archives
- XReco

- Cooperations
  - UniZH, UniFR, HES-SO
  - City Univ. Dublin, HS Düsseldorf
  - UCLA, Case Western Univ.
  - Savoir Public, 4eyes
  - GSoC (Google)
  - Digital Humanities, University Library
  - Dept. of Political Sciences
  - Historical Museum (BS), City Archive (BE)
    HEK Basel, ZKM, PTT Museum (BE), ...



- Polypheny-DB
- Polypheny-DDI
- SwissRenov
- Cooperations:
  - GSoC (Google)
  - FU Hagen
  - D-BSSE (ETHZ)
  - Dept. of History
  - Dept. of Environm. Sciences

- StreamTeam
- SportSense
- Cooperation: BaSpo

Additional Topics ...

- Collaboration with Faculty of Law, project leX-Ray: Simplifying Legal Research
- Goal: Streamline legal research for public administration by automating norm identification during legislative adjustments.
- Challenge: Manual keyword searches across Swiss legal levels (federal, cantonal, municipal) are inefficient and error-prone.
- Solution: leX-Ray, hackathon-developed, with three modules:
  - Termie: Generates keywords from project descriptions
  - Normie: Searches legal texts semantically and lexically
  - Eddie: Enables review and editing of identified norms

Image created with Mistral Le Chat
“Draw an image of a legal document in an x-ray scanner”

… Additional Topics …

- Collaboration with Adobe Basel
- Next generation of "Augmented Object Intelligence with XR-Objects"
  - Existing prototype runs on smartphones. Task: make it run on XR headsets such as Apple Vision Pro or Meta Quest 3 (with on-device AI/ML/CV)?
  - Make it smarter by integrating with more recent multimodal LLM models or AI agents for proactive user assistance
- ImprovMate: Multimodal AI Assistant for Improv Actor Training
  - Add multimodal/smart interaction capabilities
- TinkerXR: In-Situ, Reality-Aware CAD and 3D Printing Interface for Novices (using Meta Quest 3)
  - add AI features to be used in AR, such as 3D model/mesh generation based on speech/gesture/sketch/image input, e.g., using Microsoft Trellis mesh generation model
- Generative Engine Optimization (GEO) – how to optimize digital content for AI Search (e.g., ChatGPT)

… Additional Topics …

- Collaboration with the Sustainability Office at UNIBAS
  - What is the CO_2 footprint of the UNIBAS ICT?
  - What does a {Google query | ChatGPT prompt | Midjourney image | Teams call | …} cost in terms of energy and CO_2 emissions?
  - The university has a detailed environmental sustainability report …
    - … that so far however only considers buildings / heating …
    - … and air traffic
  - The objective of this project is to also make the resource use of ICT transparent!

Image licensed from Adobe Stock

… Additional Topics …

- Collaboration with the PTT Archive and wikimedia CH
  - make content of the PTT archive
  - and in particular artworks made out of PTT content

  accessible in a virtual museum

Image source: post.ch

… Additional Topics

- Work with our new member: DiMI, the humanoid robot of the DMI (type: TIAGo)
  - Add conversational interfaces
  - Support navigation inside the DMI
  - Make it fit to host events (Fantasy, Info Day, etc.)
  - … and whatever you could think of

University of Basel

Thank you for your attention!

contact: dbis@unibas.ch