Data Integration

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Universitat Politècnica de Catalunya

A Framework to Characterize the Problem

DATA INTEGRATION

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Dealing with *external* data as first-class citizen

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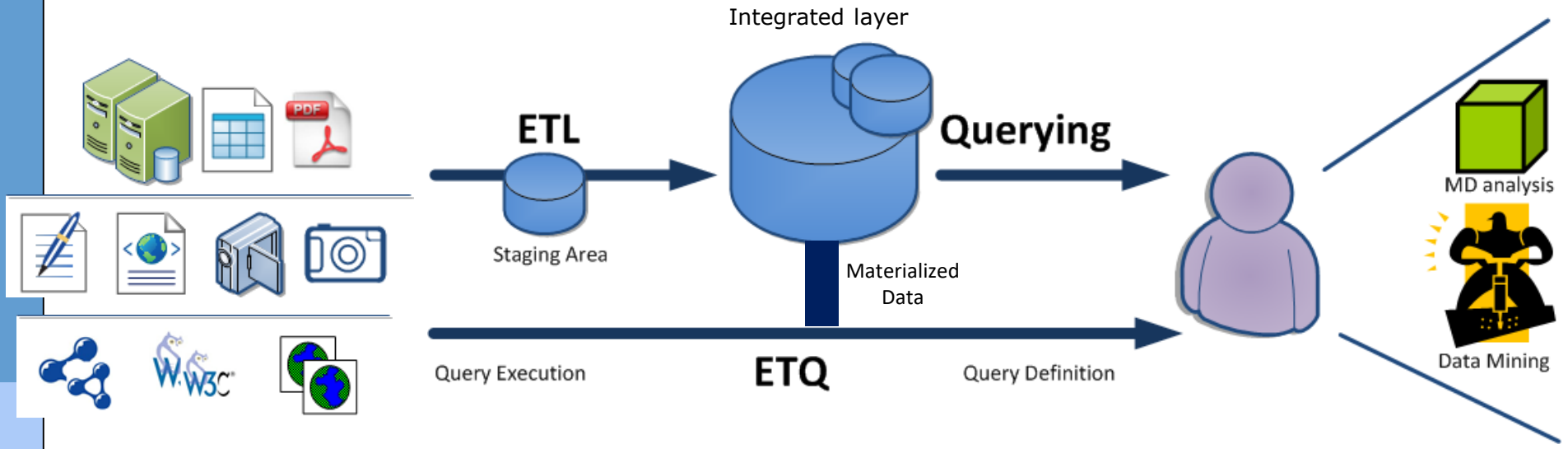
  - Integrate the data in a common repository **_Right-time_ data integration (i.e., automation is a must)**
  - Query and exploit the data **Deterministic Vs. Undeterministic "queries"; Personalisation / recommendations**

The Theoretical Problem: Data Integration

3 MAIN CONSTRUCTS:



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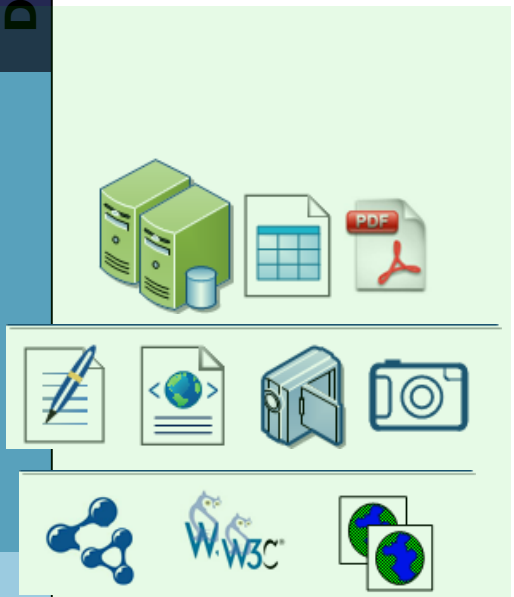
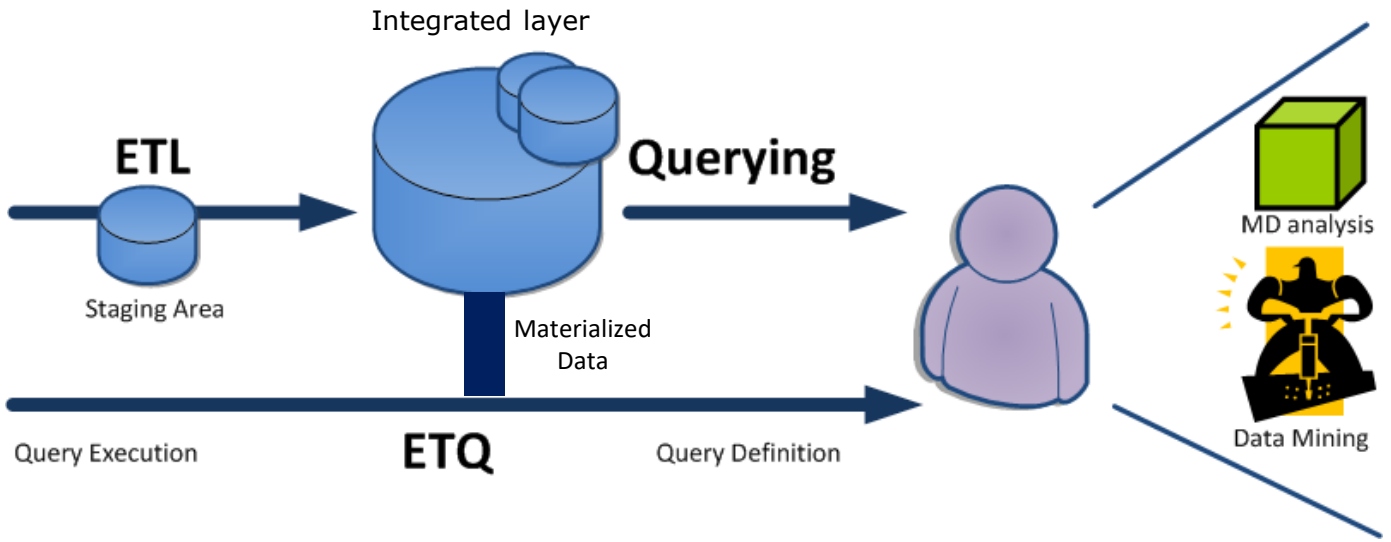


DATA SOURCES SCHEMATA



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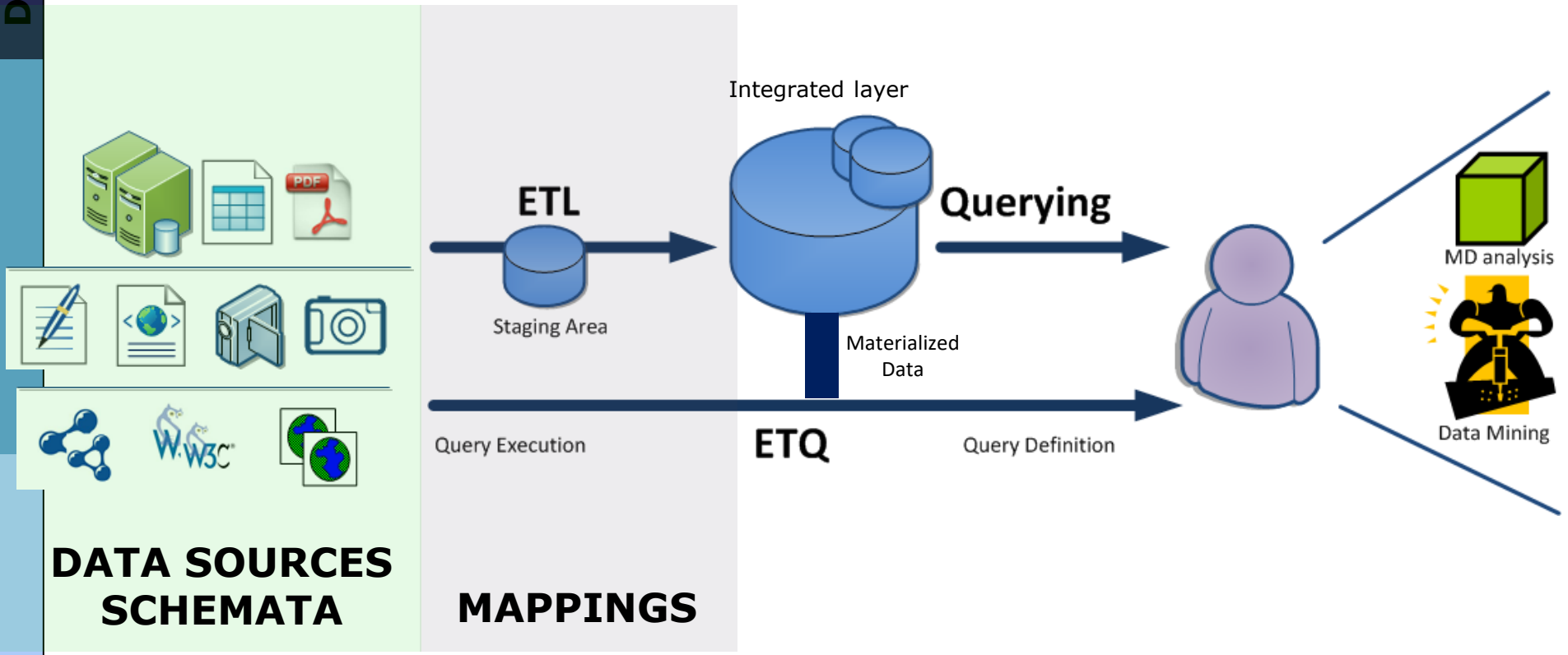

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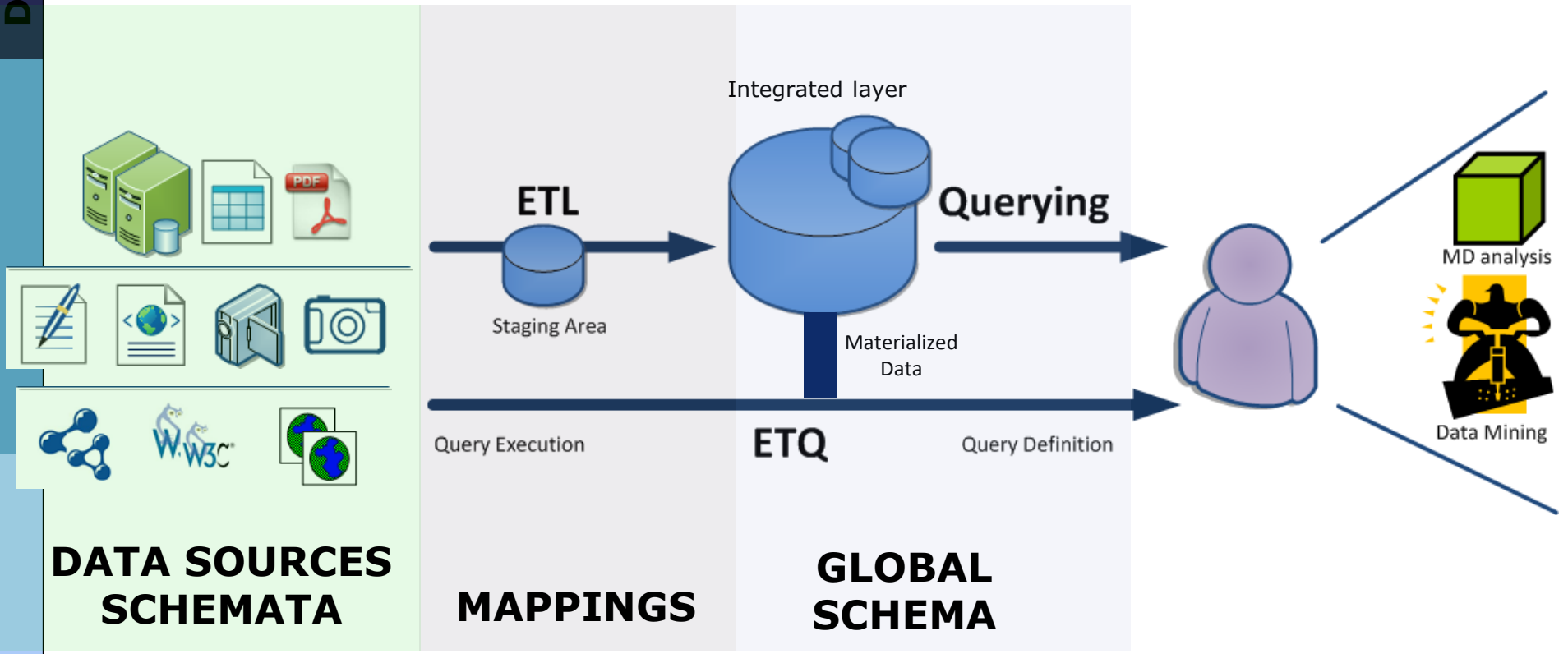

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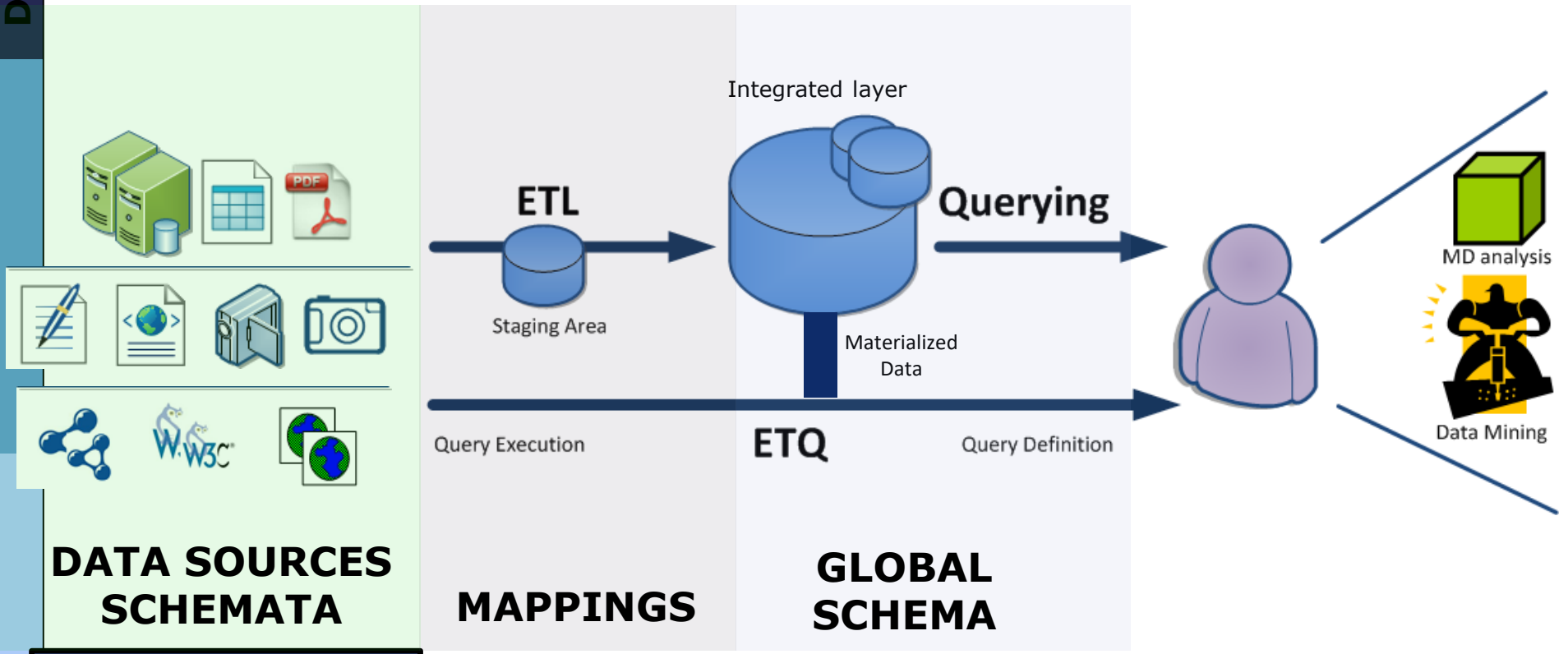

Data Source Layer

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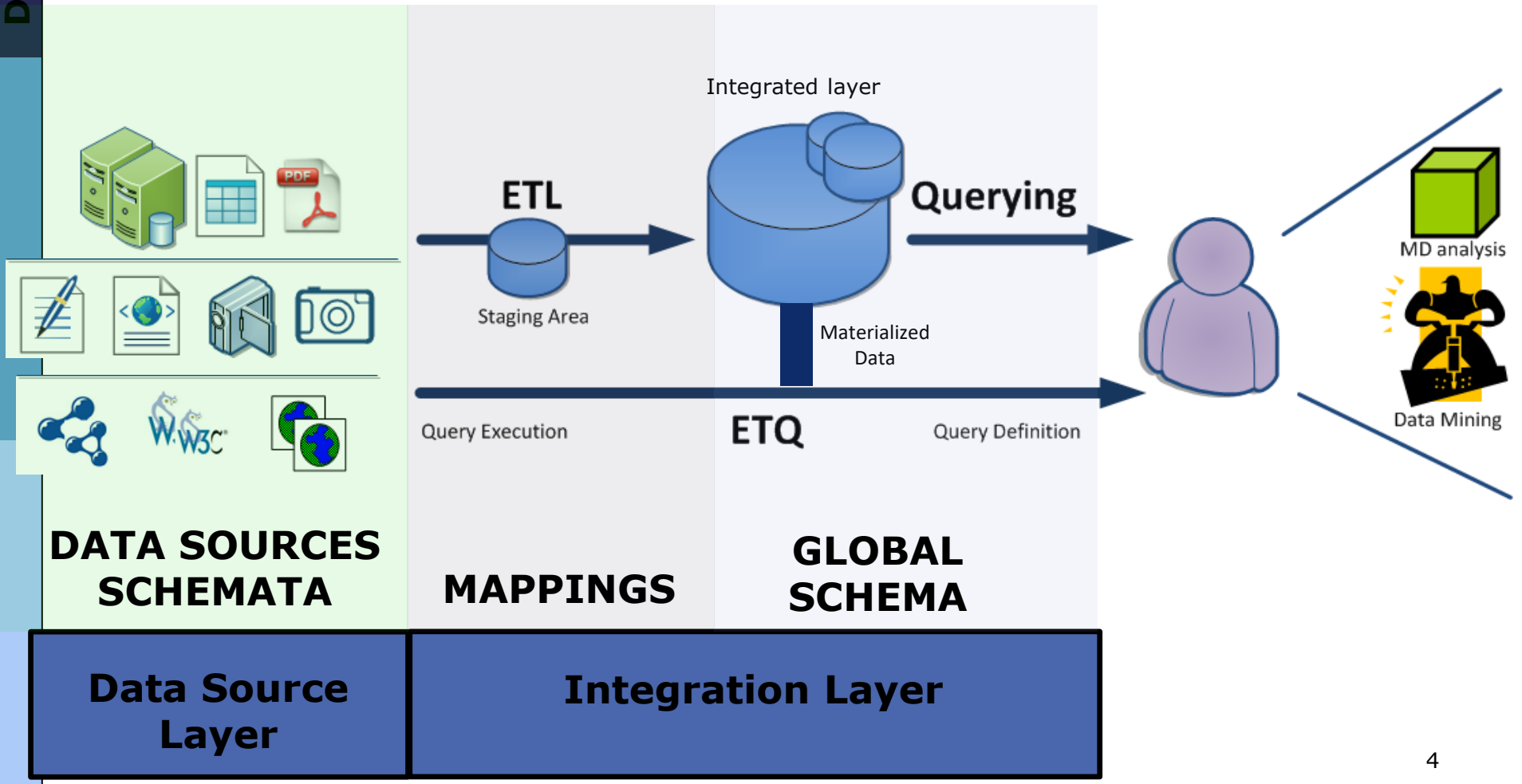

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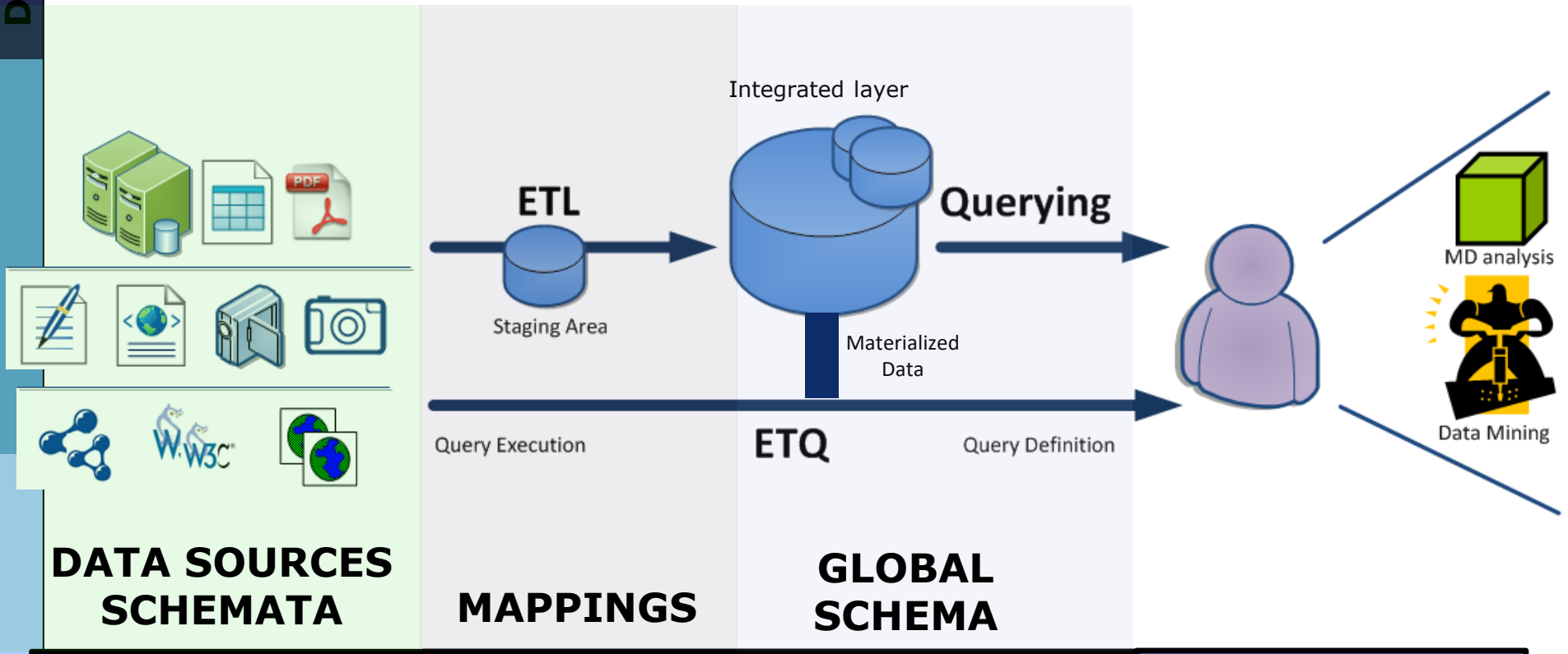

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USER FEEDBACK PRODUCT INFO USER WEB BEHAVIOUR

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Twitter API
(JSON)

USER FEEDBACK

In-house DB
(PostgreSQL)

PRODUCT INFO

Web Logs
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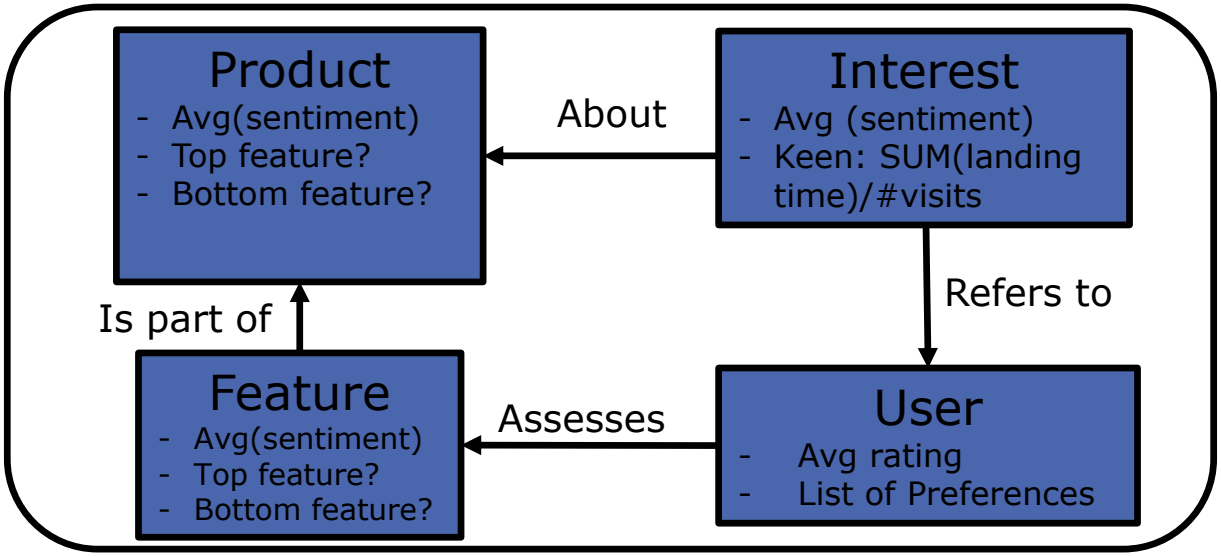

- User
- Tweet
- Date
- Location

Twitter API (JSON)

USER FEEDBACK

- Product
- Product features
- User info

In-house DB (PostgreSQL)

PRODUCT INFO

Web Logs (Logs)

USER WEB BEHAVIOUR

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- Product
- Landing time
- rating

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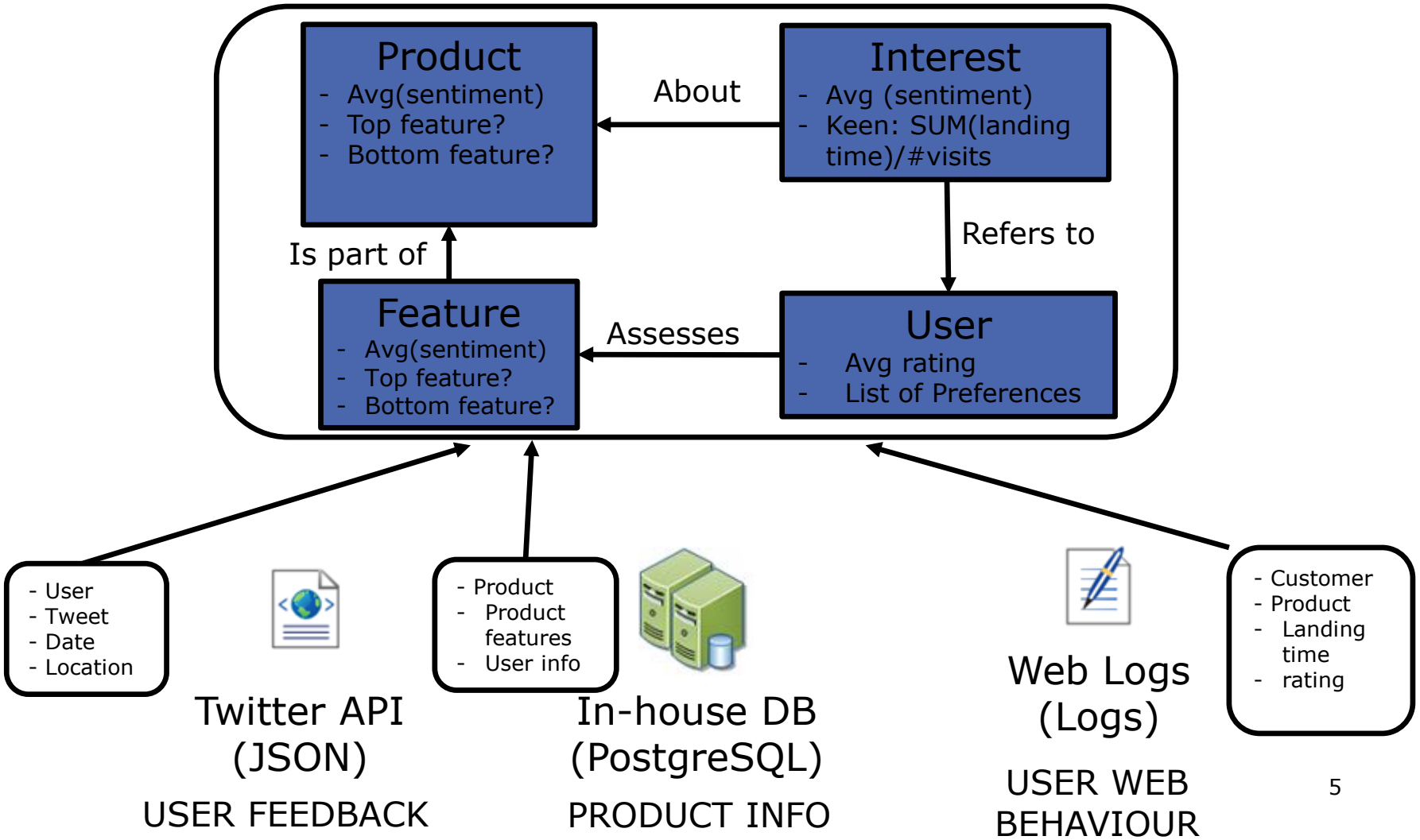

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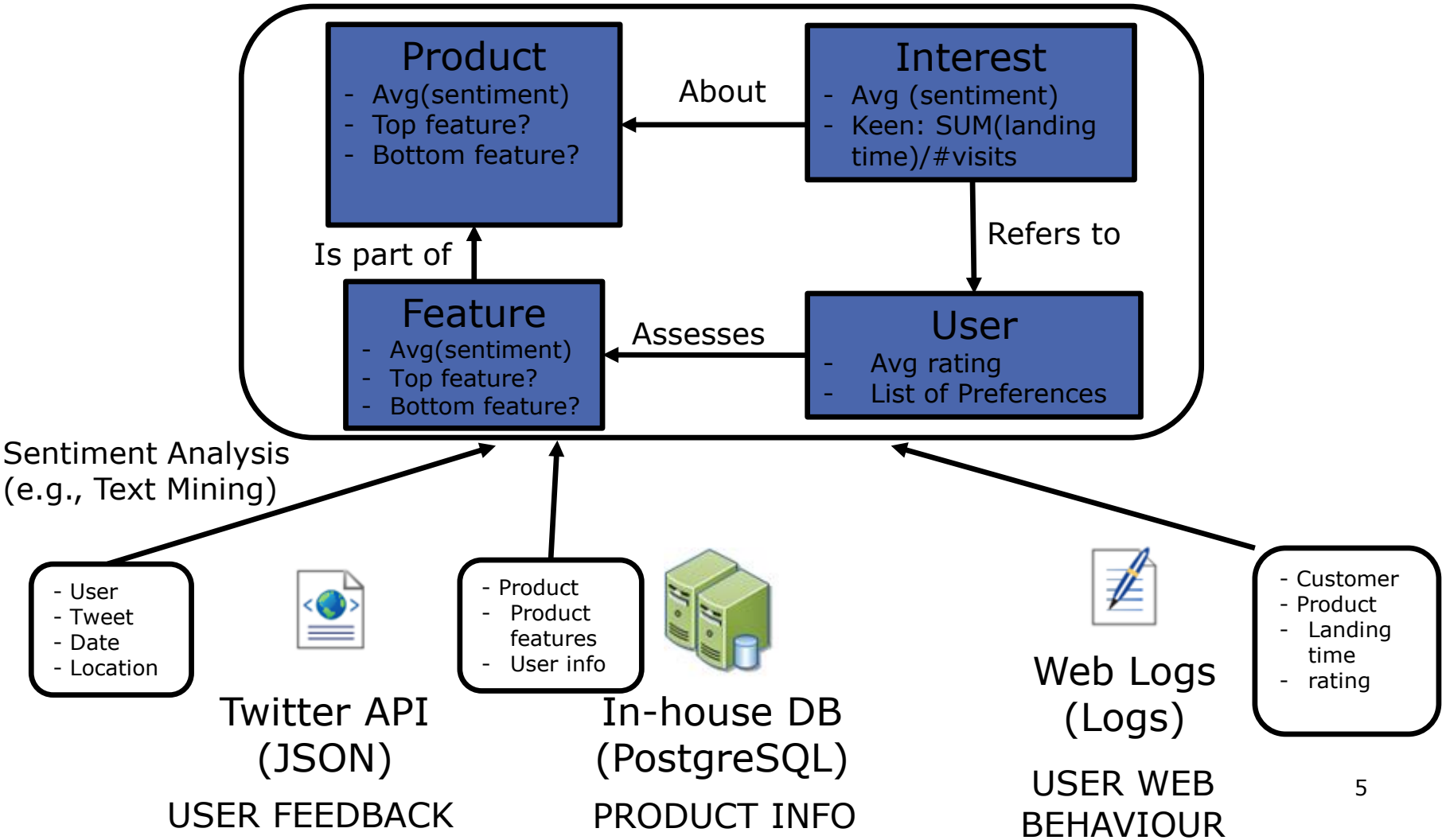

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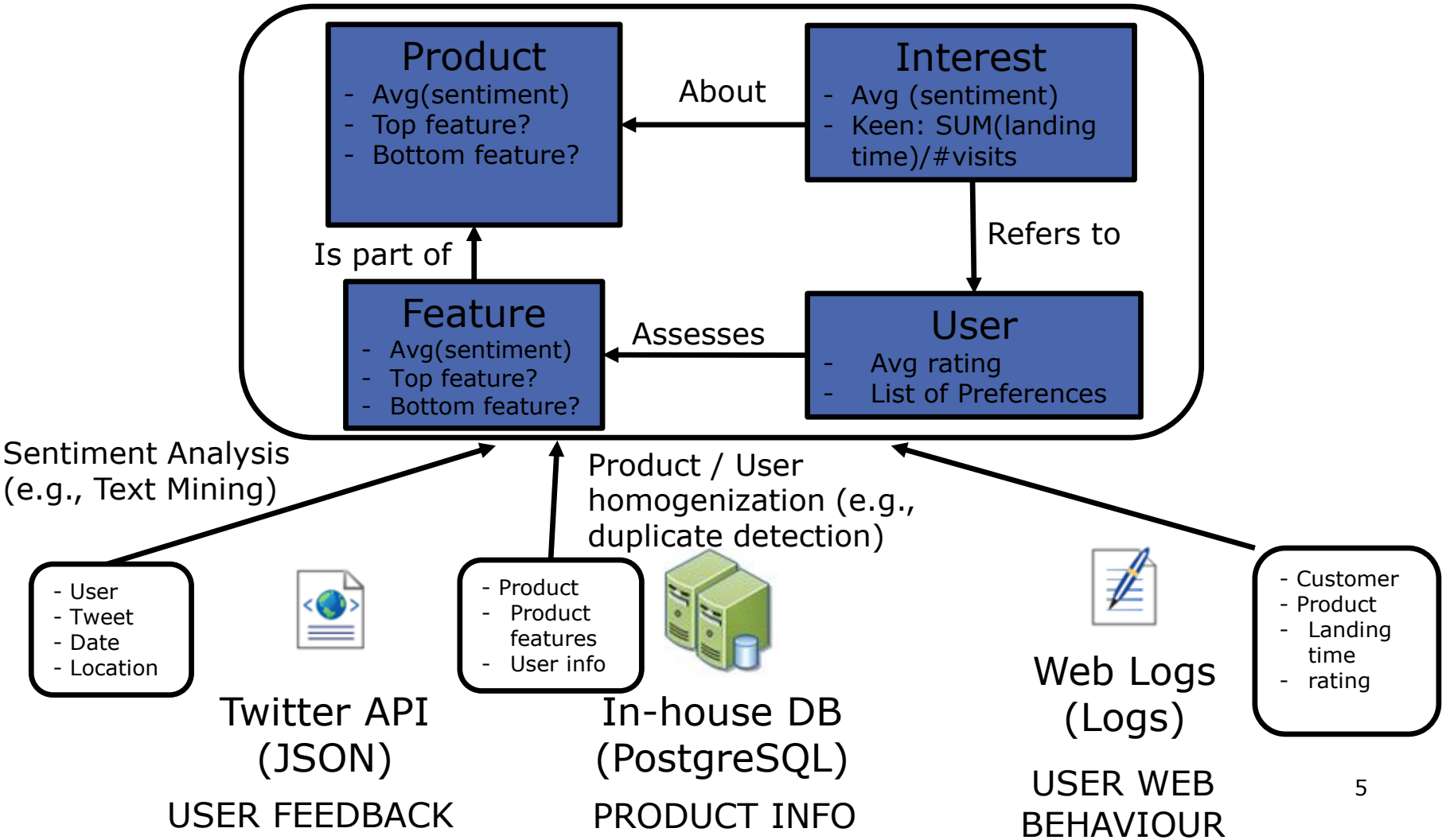

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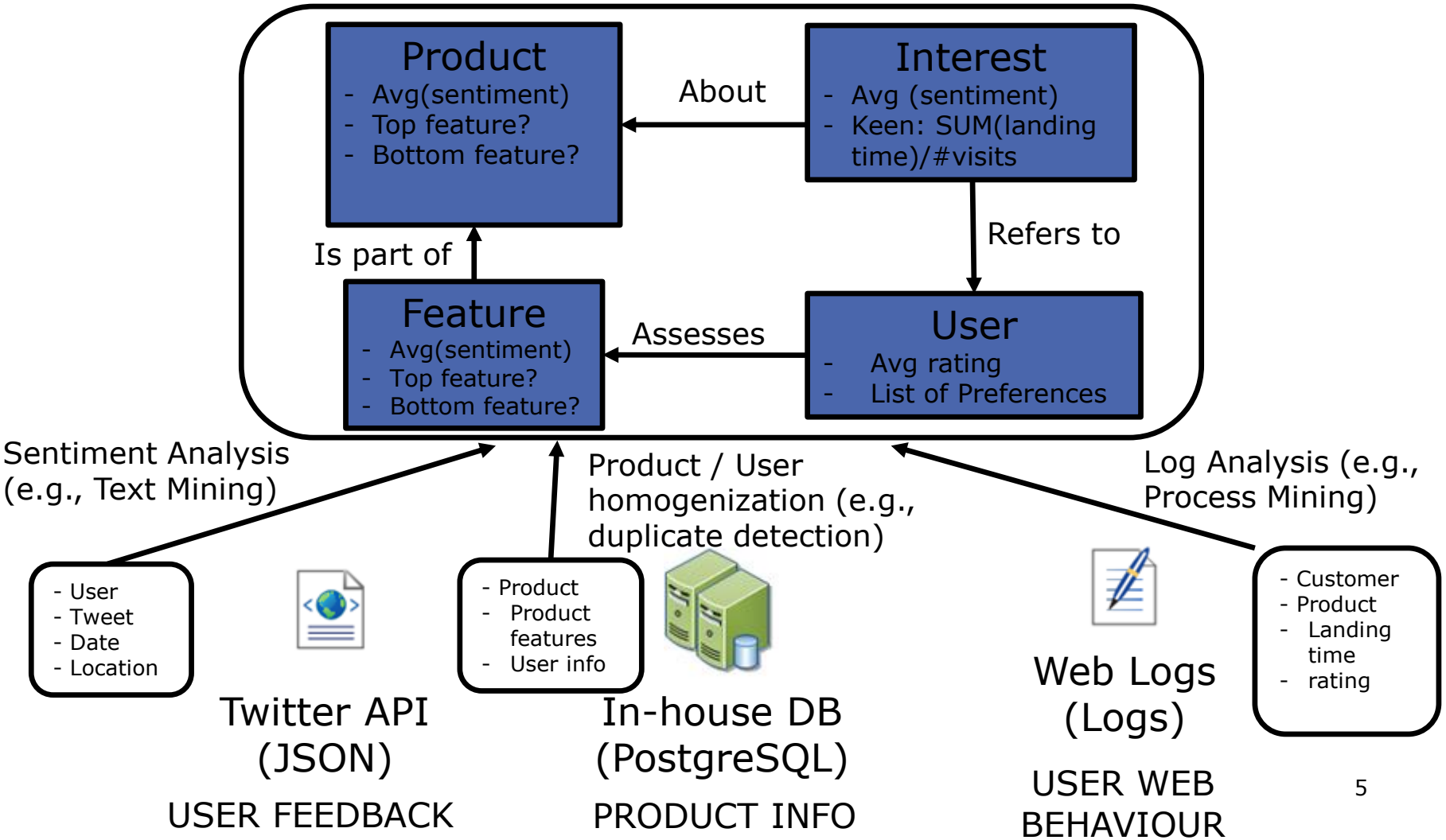

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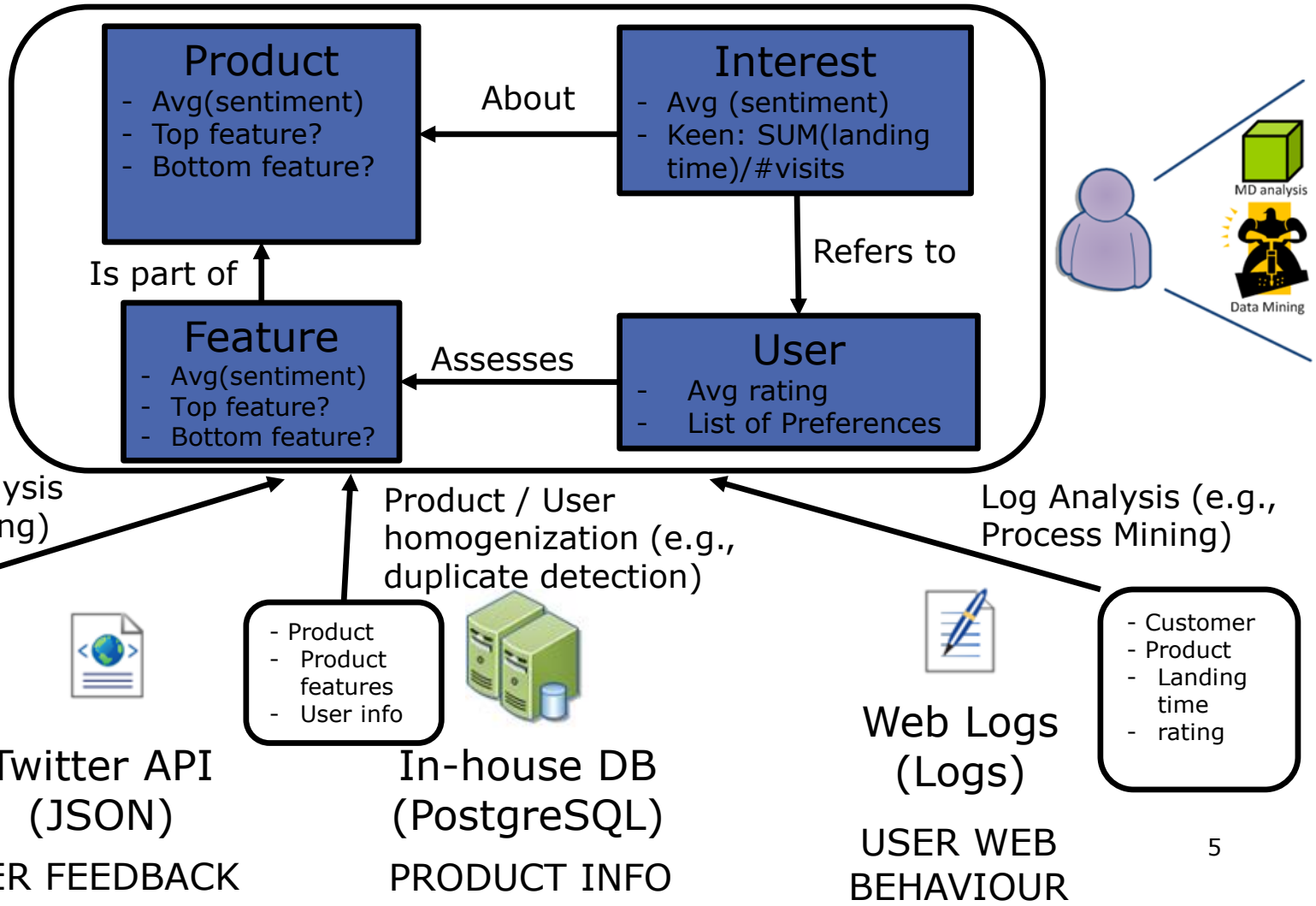

Data Integration Example

- Interest is every event detected in the web relating a user with a product
  - For each pair user-product, if we have identified the Twitter user, we extract the average sentiment by mining his tweets about that product
  - His / her keenness is computed by the ratio total landing time and number of visits
- Assessments are extracted, by means of data extraction techniques, from the user tweets about product features
  - For each feature, from all the assessments, we compute its average sentiment
  - Interest is every event detected in the web relating a user with a product
  - For each pair user-product, if we have identified the Twitter user, we extract the average sentiment
  - by mining his tweets
  - The top 5% features with higher sentiment are top features; similarly for bottom features
- Products compute their average sentiment from the tweets about them or about their features (features are weighted)
  - For each products, its bottom and top feature is identified (min and max sentiment, respectively)
  - Products and product features are deduplicated (in the source, several items may refer to the same product or product feature)
- Users are those from the database, who logged in the web. In addition, we may have info about their Twitter account
  - We trace the users in the web, and for each visit to the Web we generate a log line as follows: <user, product, landing time, rating>
  - The user list of preferences results from normalizing those products in the Web they visited and rated above his rating standard deviation

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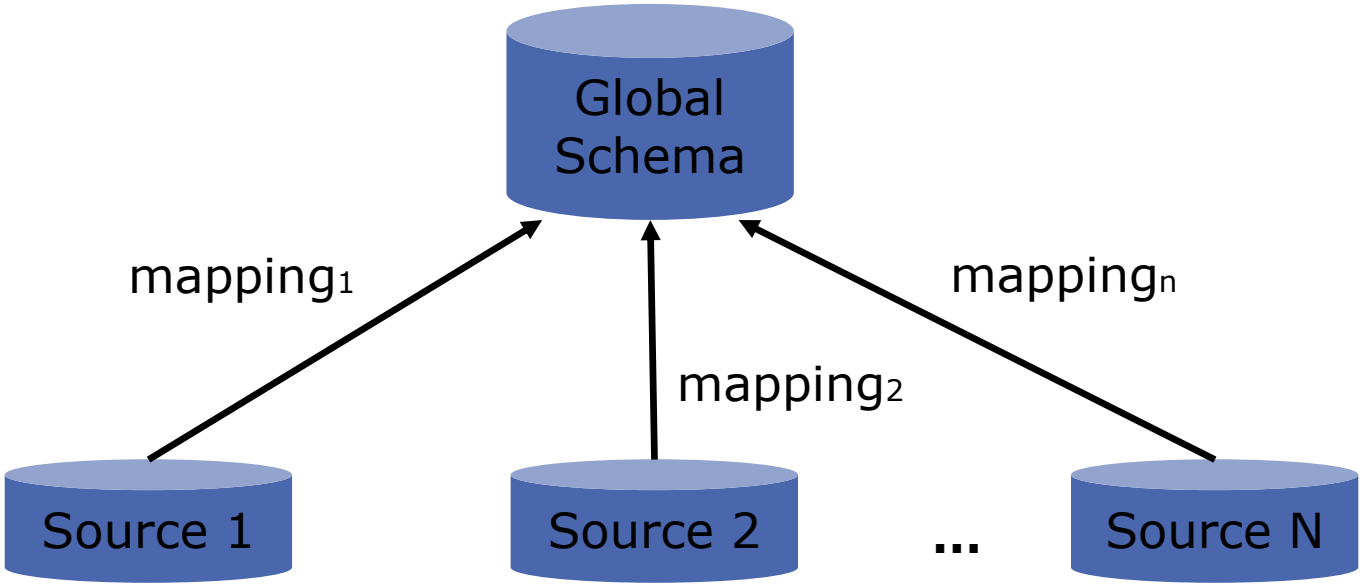

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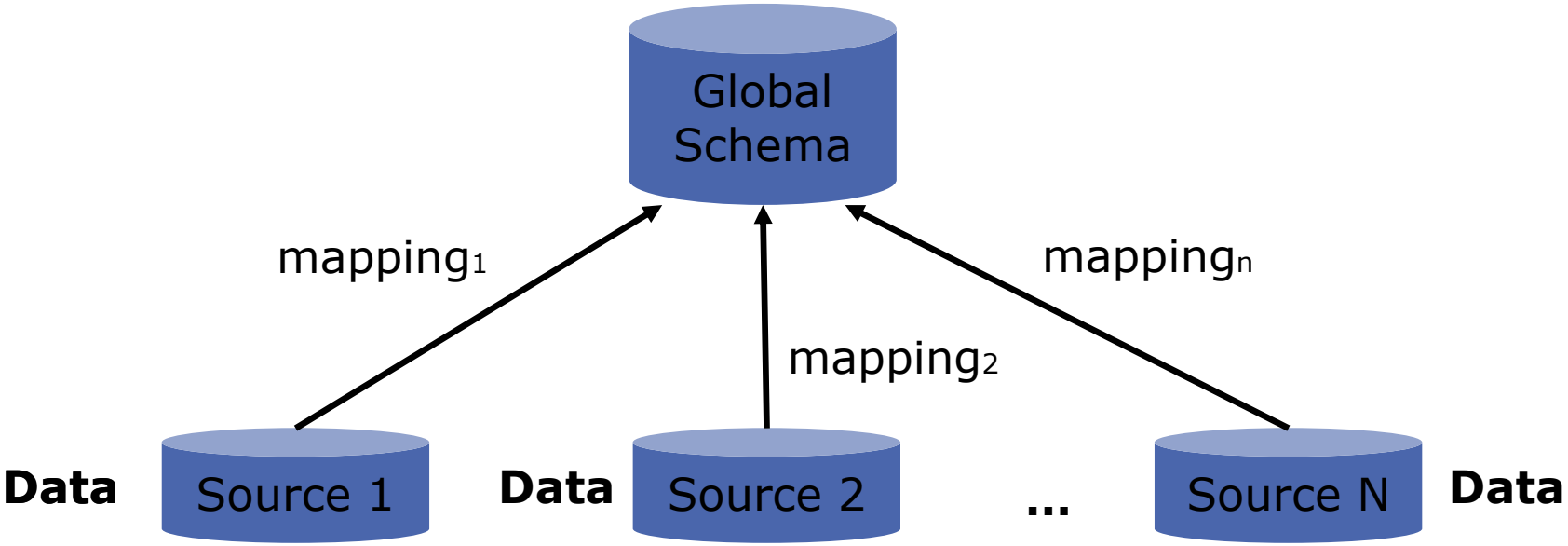

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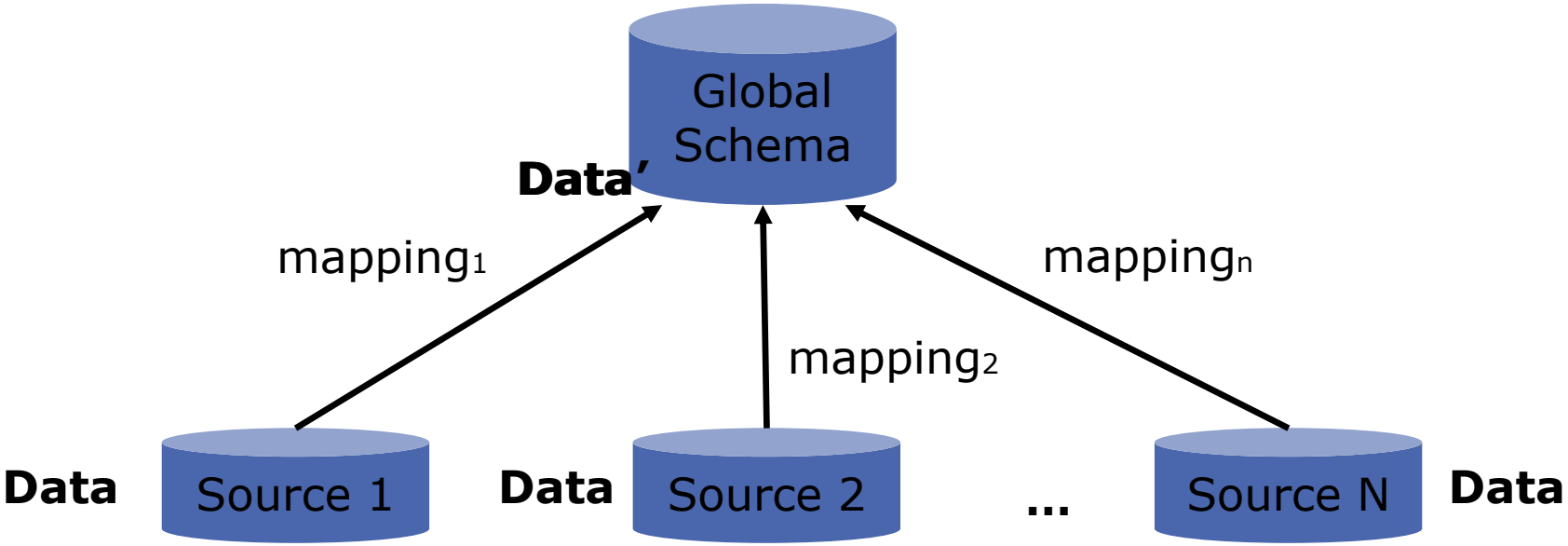

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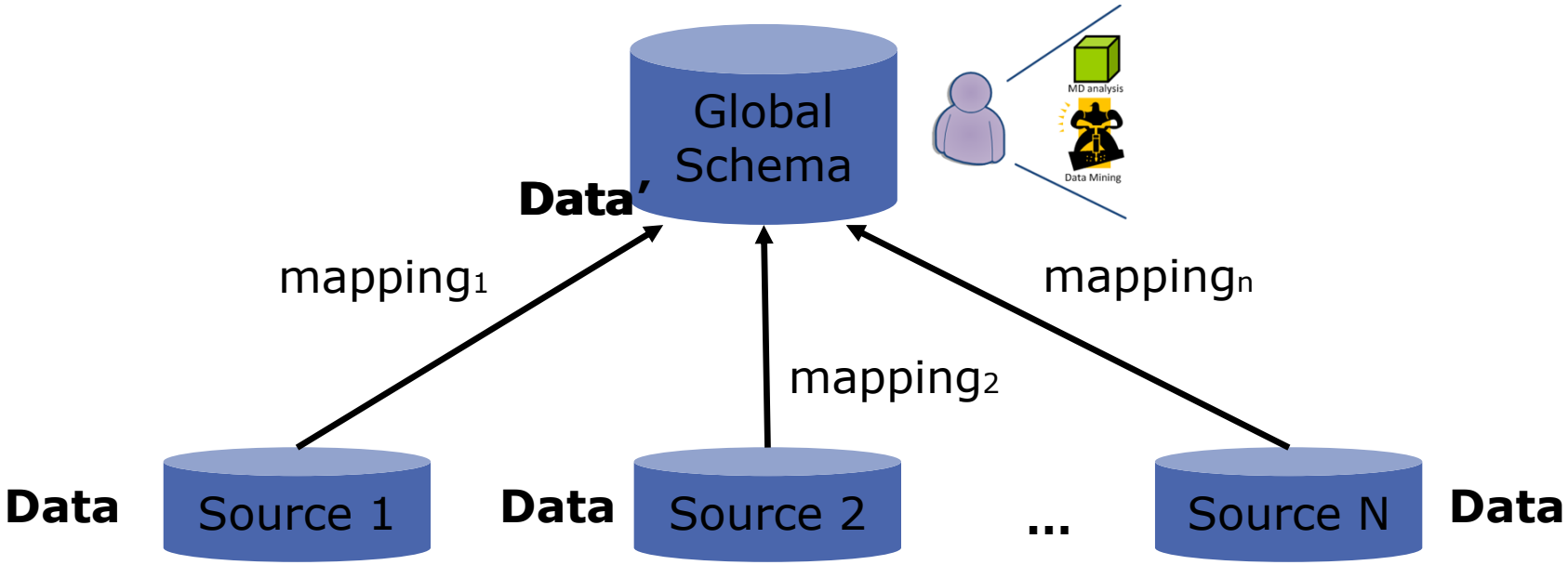

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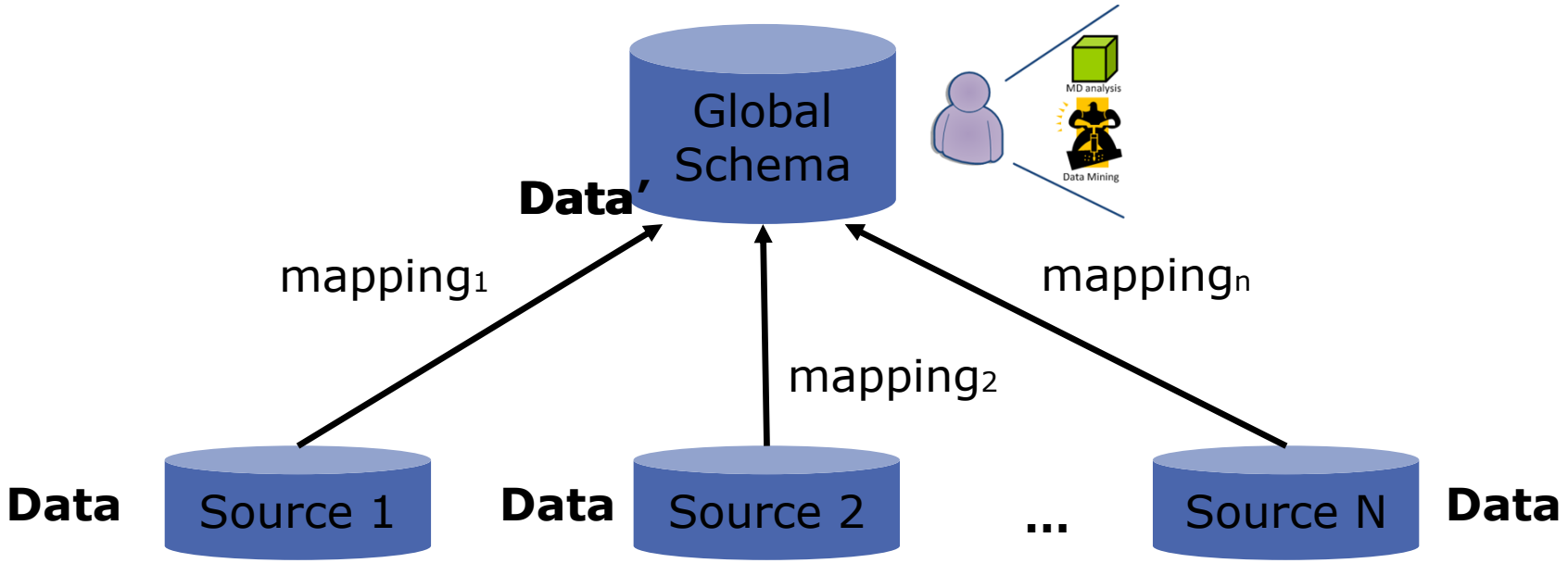

Note that the mappings are created and coded in design time. Thus, they become simpler as the system only need to run them (no need to generate them on-the-fly)

Example: Data Warehousing

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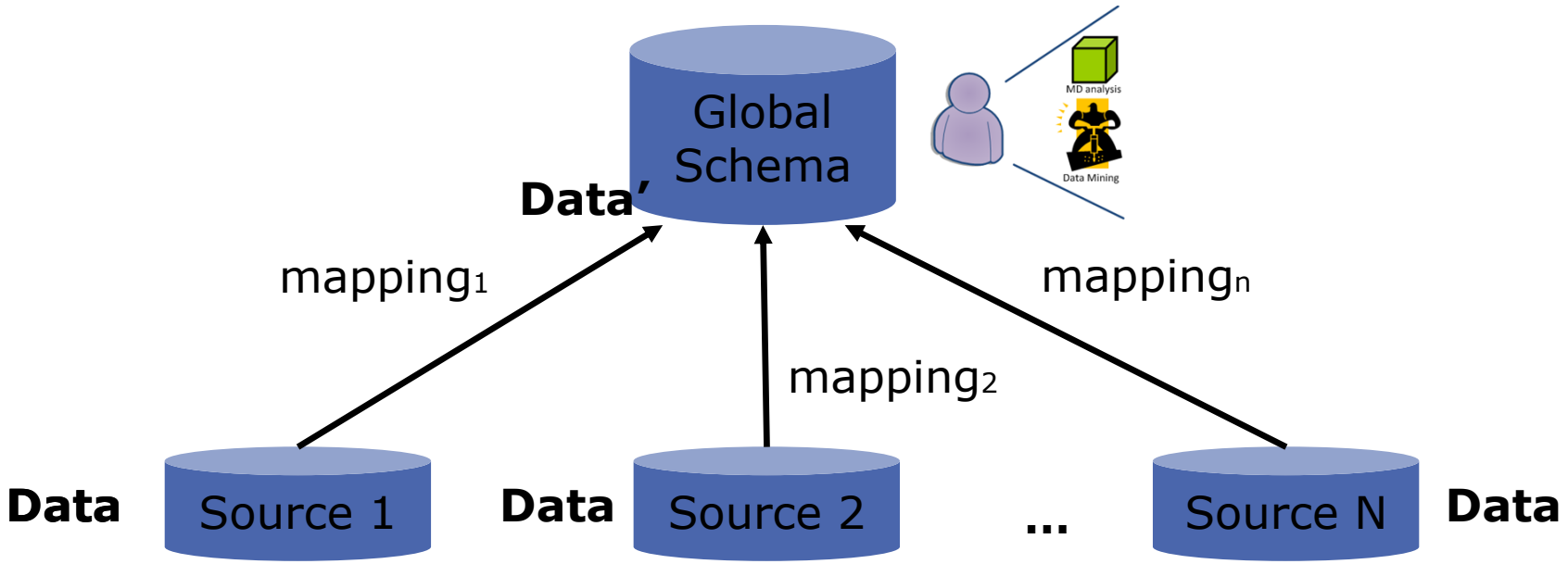

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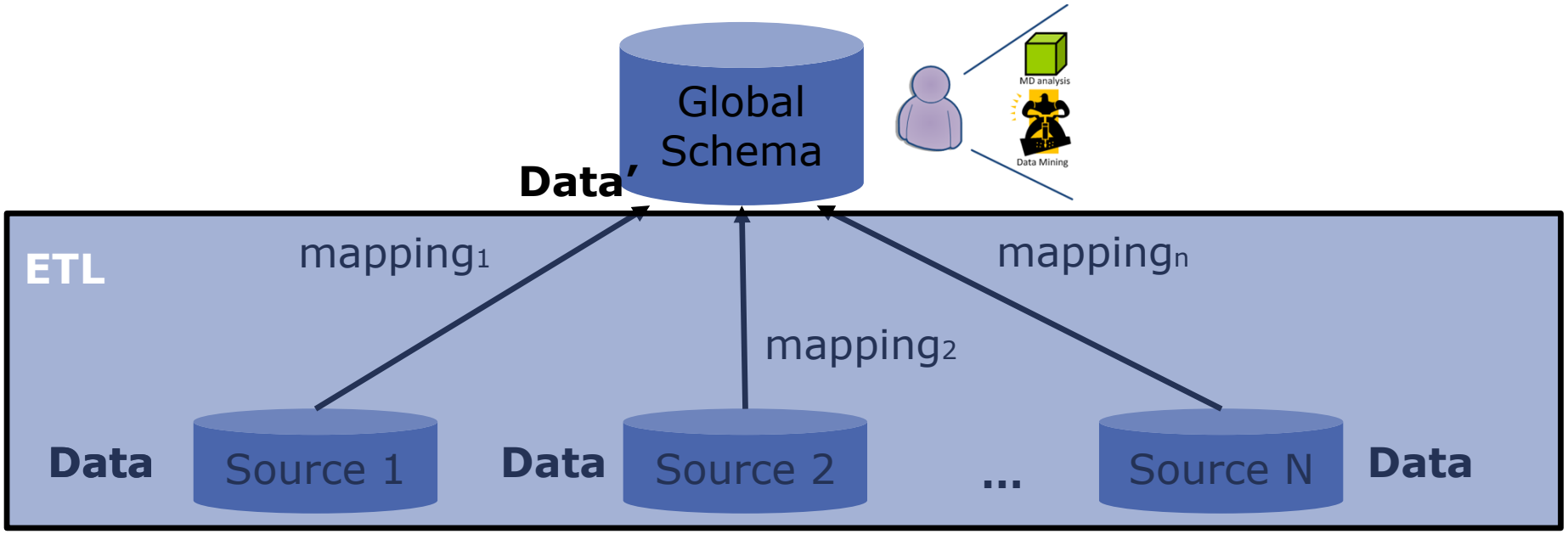

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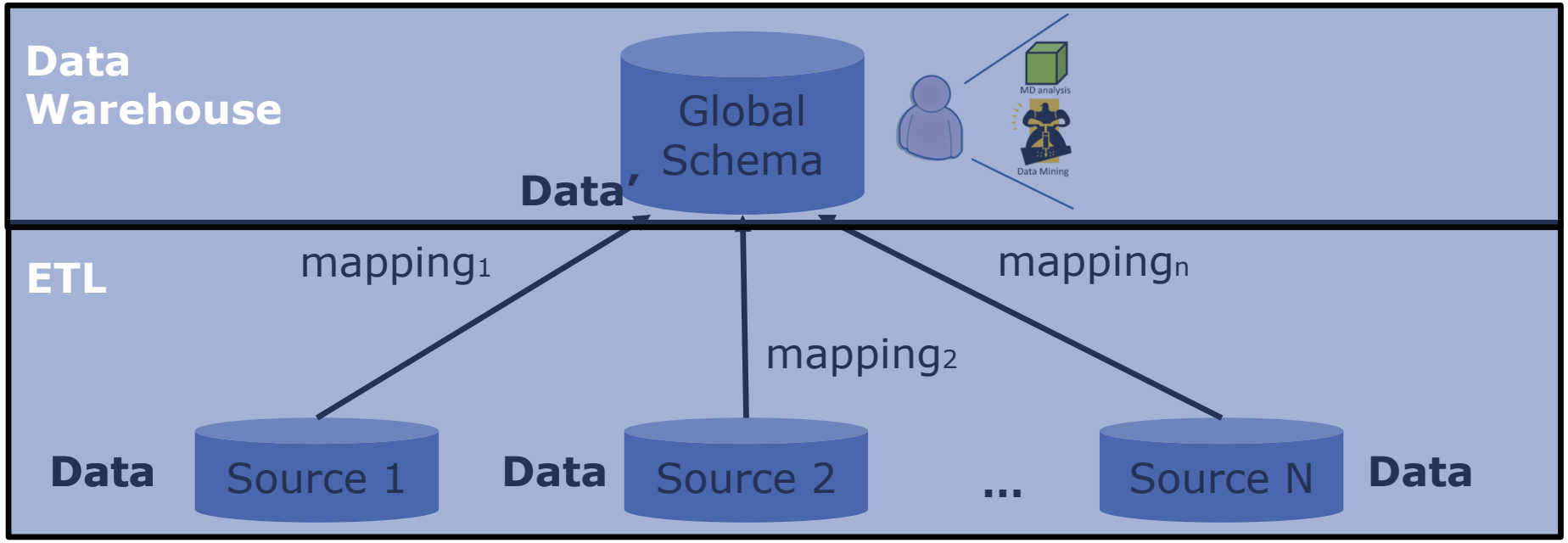

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Activity: Physical Integration

- (15') Understand the main constructs behind physical data integration
  - (10') Consider the example introduce:
    - Choose two concepts and one relationship
    - Draw correct ETL flows from the sources to the integrated layer. A correct ETL:
      - relates the target attributes with the corresponding data source attributes
      - Applies a sequence of ETL operators. As a recall, the most typical ETL operators are:
        - Algebraic / relational operators
        - NLP constructs (remove stop words, tokenize, stemming, lemmatize, etc.)
        - Data mining / machine learning algorithms
        - User-defined functions (e.g., parsing, ad-hoc code, etc.)
- (10') Brainstorming

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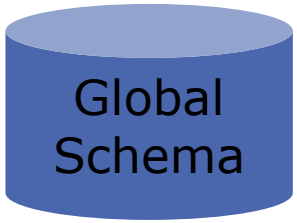

In the mappings, the global schema is defined as a view over the sources

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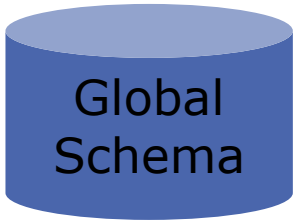
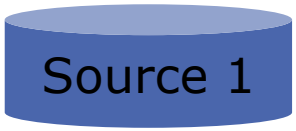
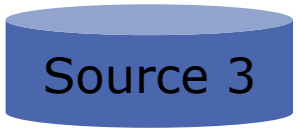
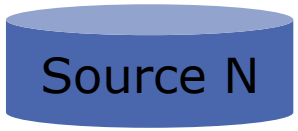


Data  **Data**  **...**  **Data**

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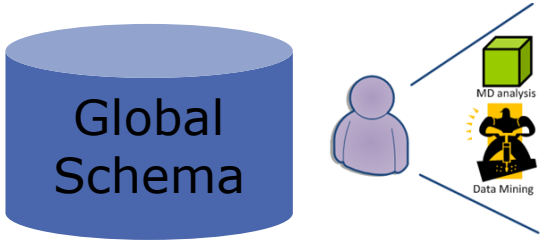

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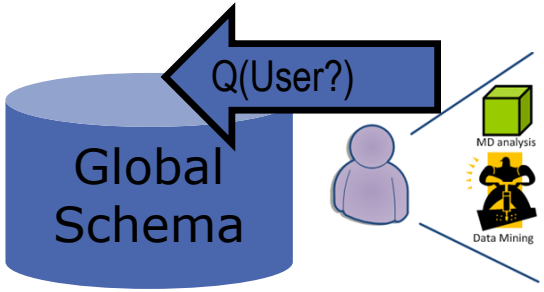

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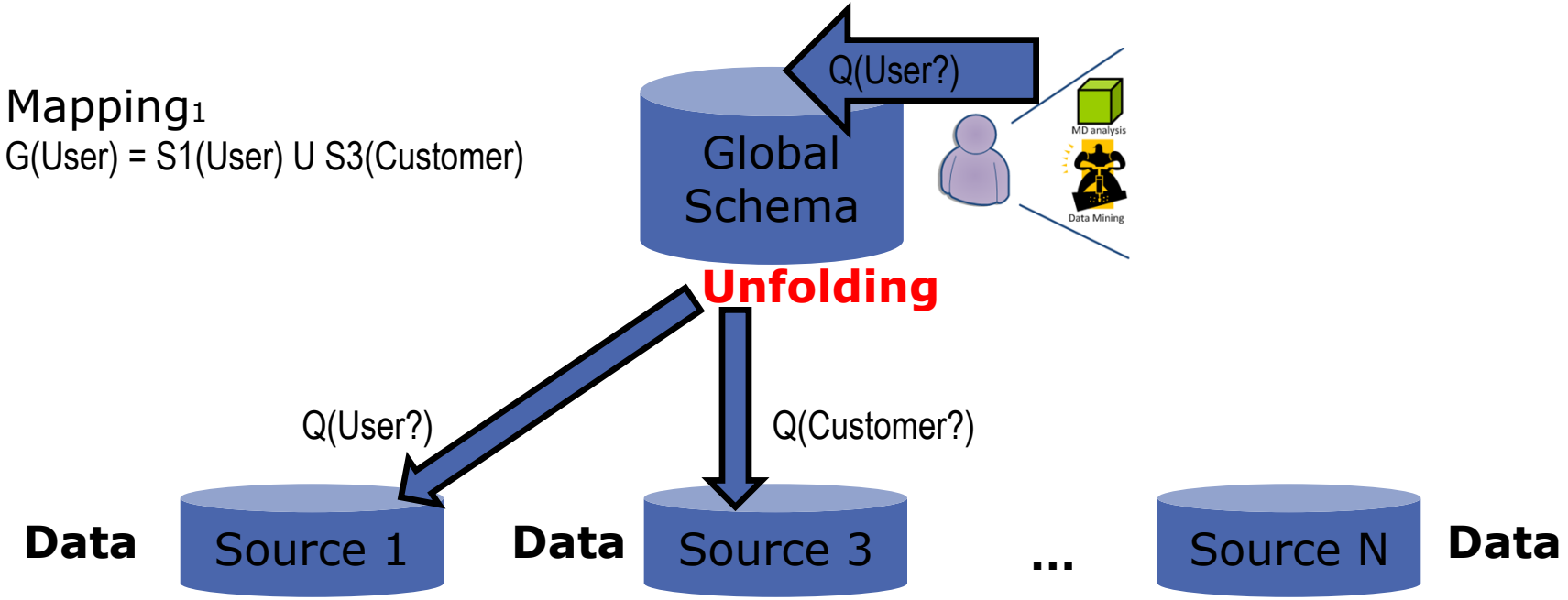

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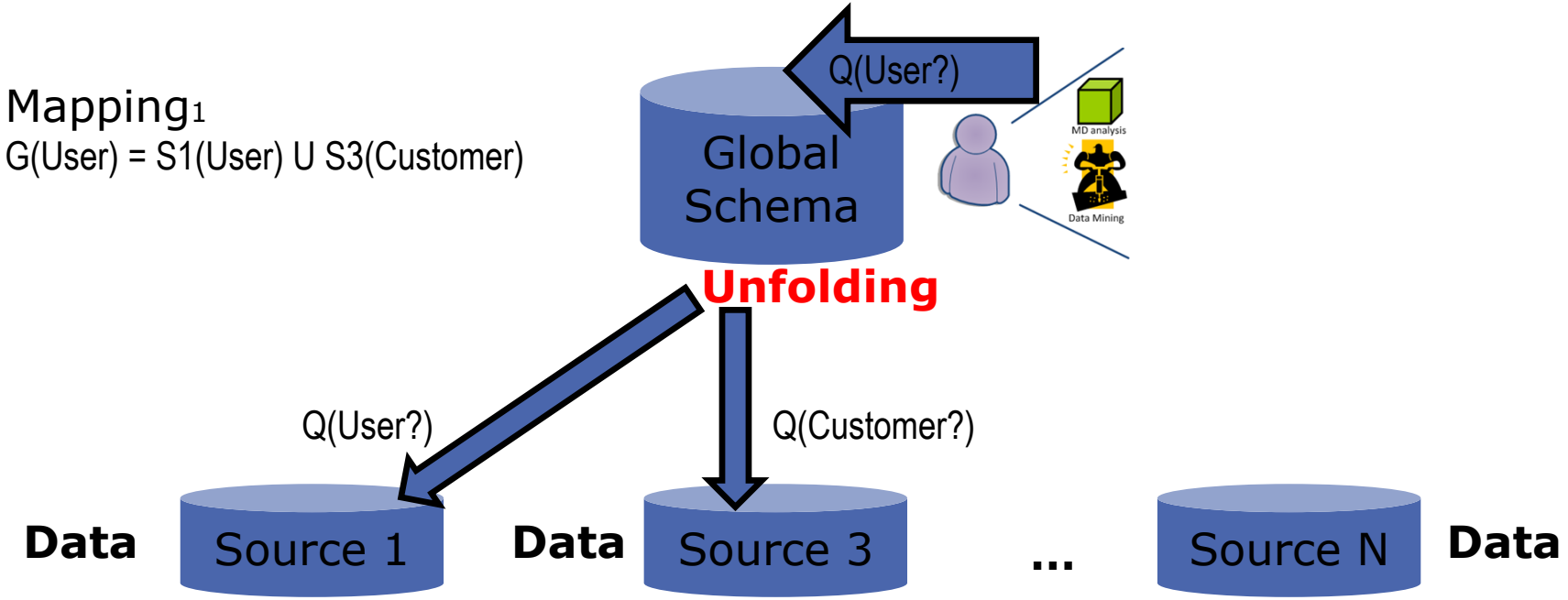

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In this case, querying is reduced to unfold the mapping (same theoretical problem as querying views)

Activity: Virtual Integration + GAV

- (5') Understand the main constructs behind virtual data integration
  - (10') Consider your previous :
    - How would the GAV mappings from the target concepts and relationship chosen would look like?
    - Do they resemble the ETL flows? What is similar / what is different?
- (5') Brainstorming

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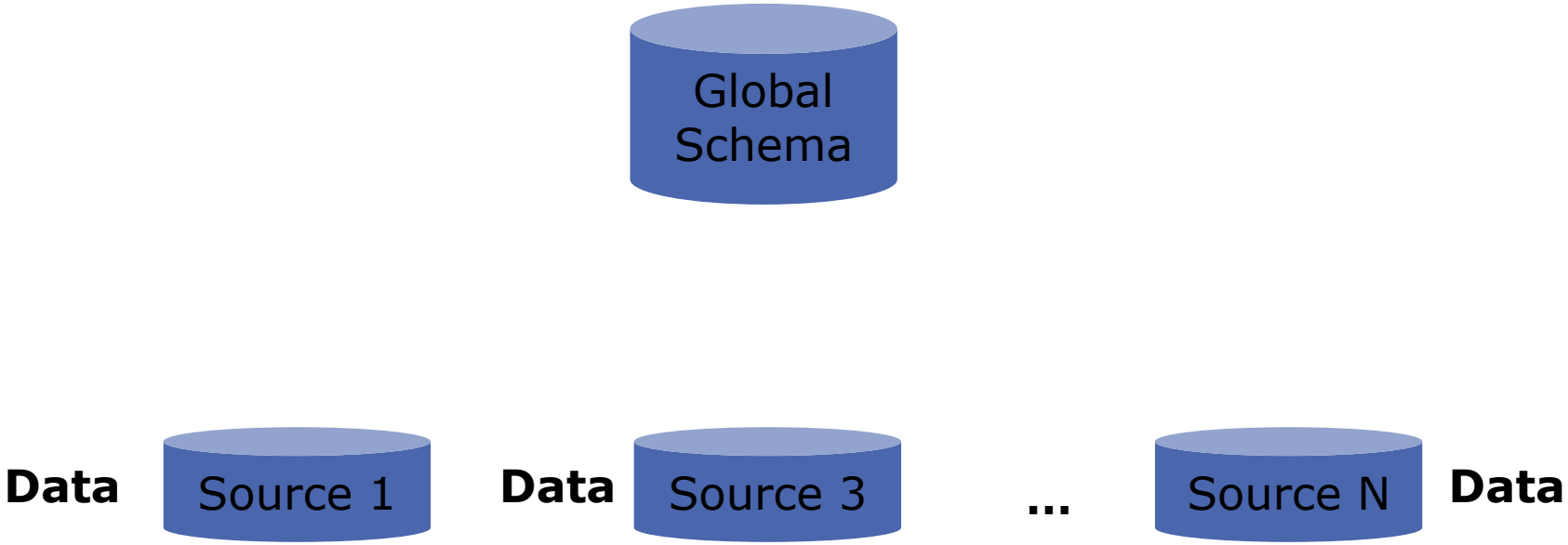

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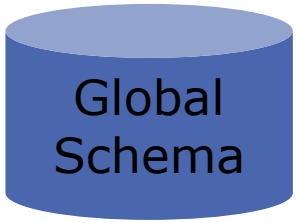
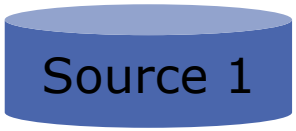
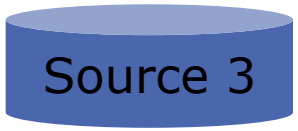
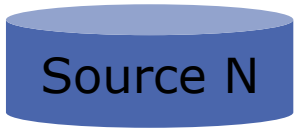


Data  **Data**  **...**  **Data**

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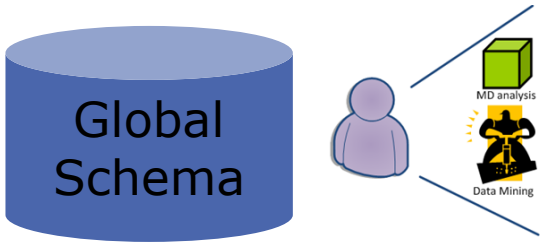

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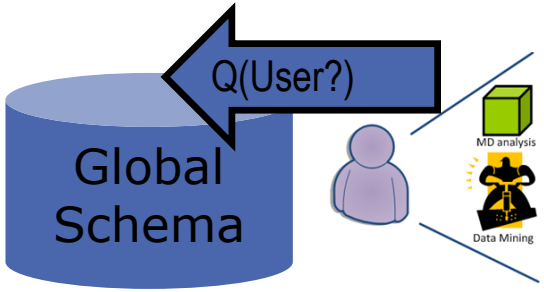
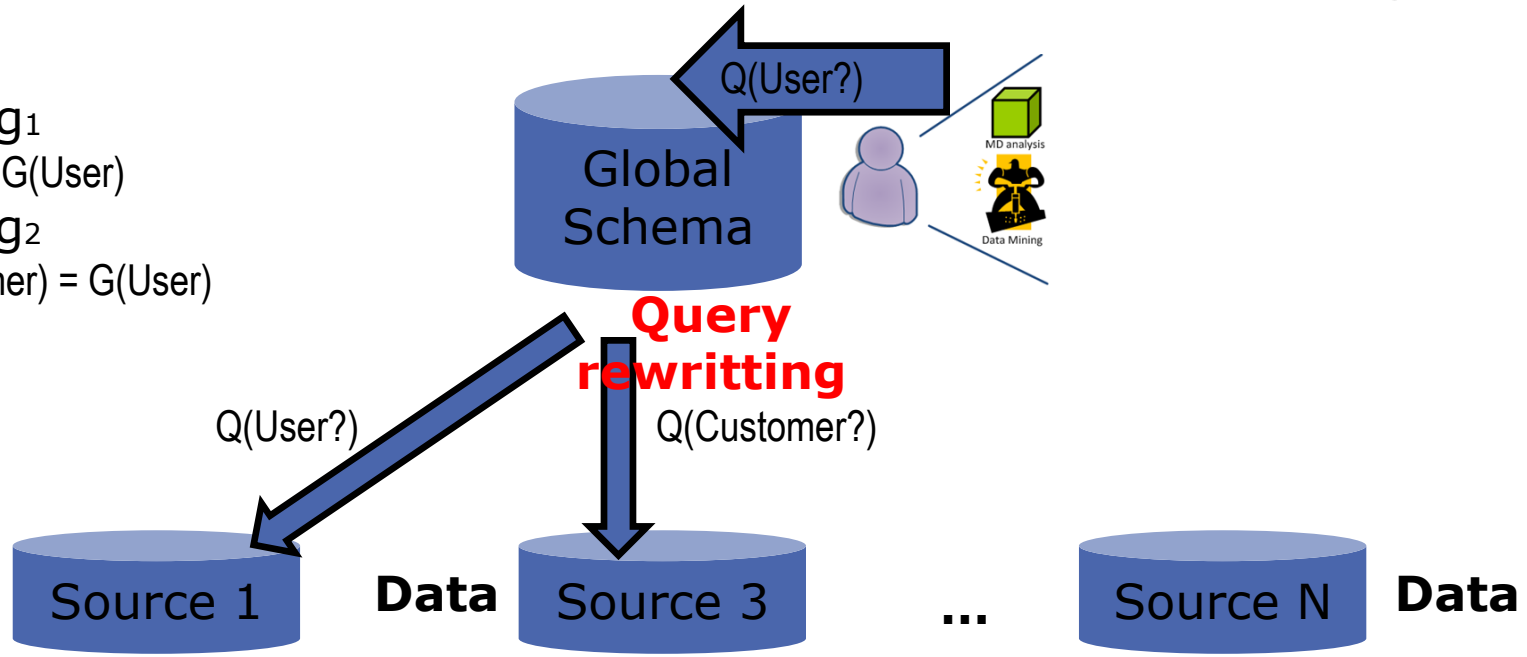


In the mappings, the local schemata are defined as views over the sglobal schema

Basics on Data Integration

- Two main decisions to call:
  - **Virtual** Vs. physical integration
  - Global-As-View Vs. **Local-As-View** mappings

Mapping$_1$
S1(User) = G(User)
Mapping$_2$
S3(Customer) = G(User)



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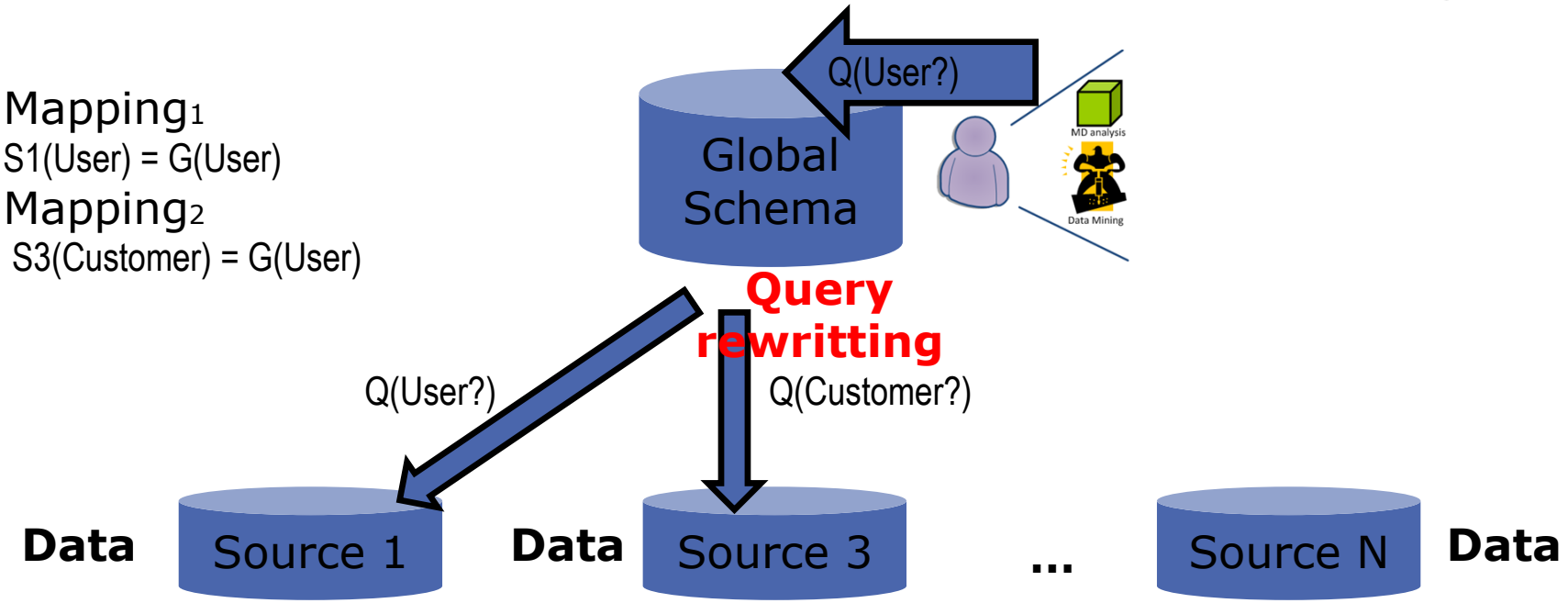


In the mappings, the local schemata are defined as views over the sglobal schema

In this case, query rewriting techniques are needed to transform the query into a set of queries over the sources (logics needed!)

Unleashing the Power of LAV

- Consider the following relational view on top of the Web Logs source:

  (customer, product, landingTime, rating)

- And the following mappings:

(customer) :-> (user)

(product) :-> (product)

(customer c, product p) :-> (product p, interest c/p, user p)

(customer c, product p, SUM(landingTime)/COUNT(c, p) k) :-> (product p, interest c/p, user p, keen k)

- And the following queries:
  - Q(user?) and Q(product?)
  - Interest(product p, user u, keen k)?
  - Interest(user u, product p)?
- How would the query rewriting algorithm look like?

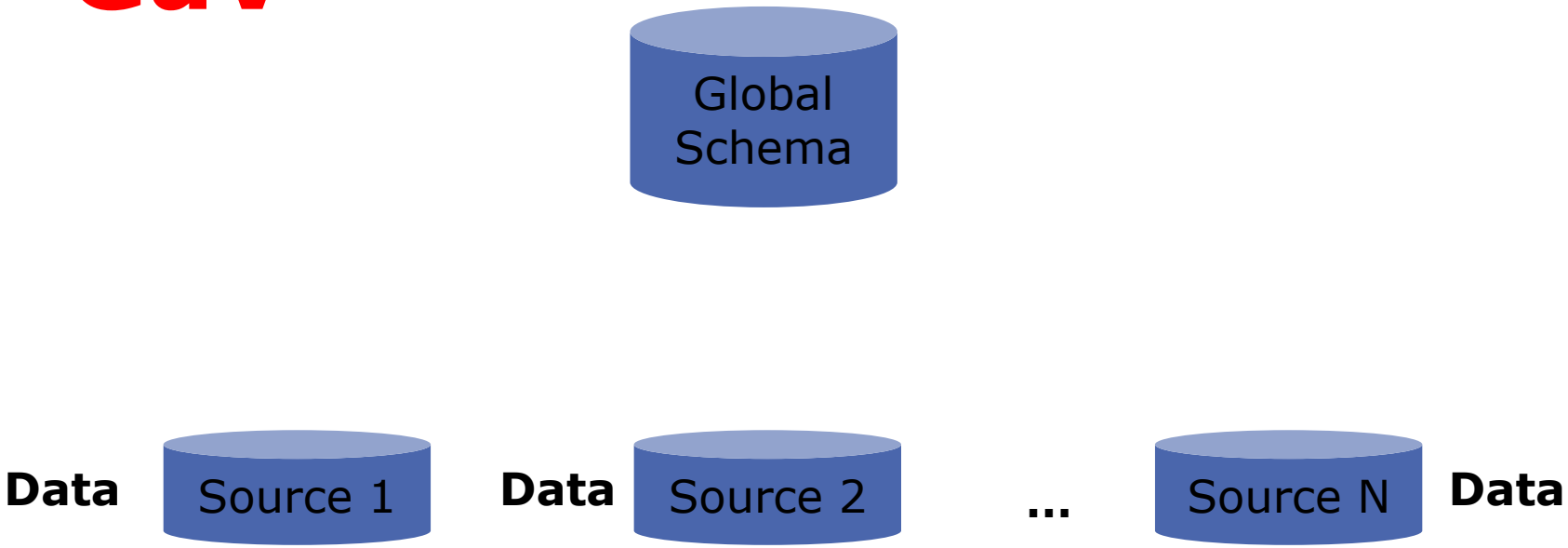
Activity: Virtual Integration + GAV

- (5') Understand the difference between LAV and GAV
  - (10') Consider the previous slide:
    - Considering the corresponding GAV mappings, would you be able to answer the following query?
      - Interest(user u, product p)?
      - Why?
- (5') Brainstorming

Basics on Data Integration

- Why LaV is much more complex than GaV in the general case?

GaV



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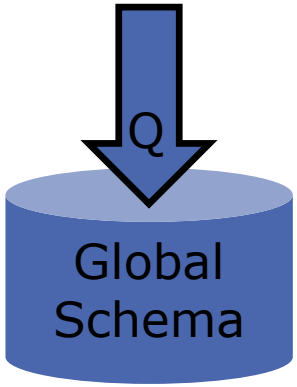

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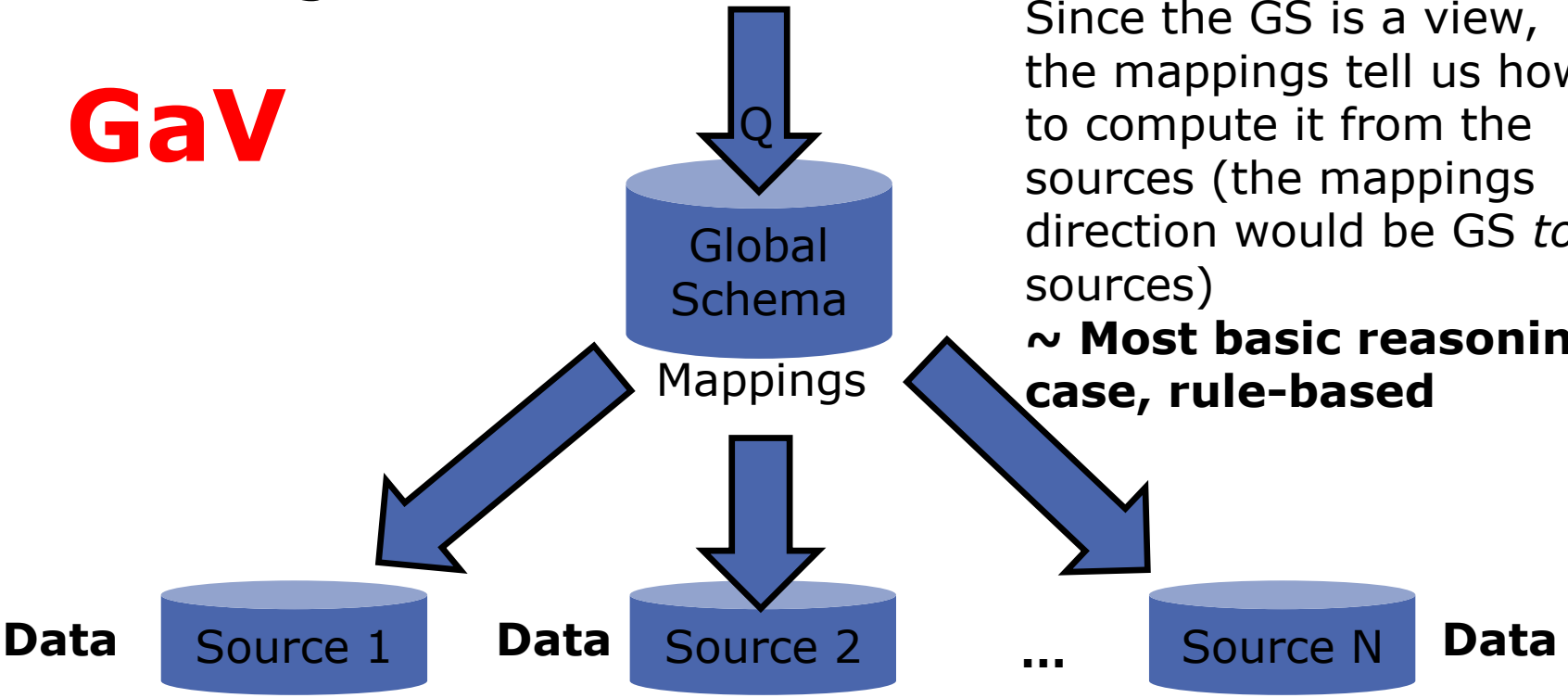


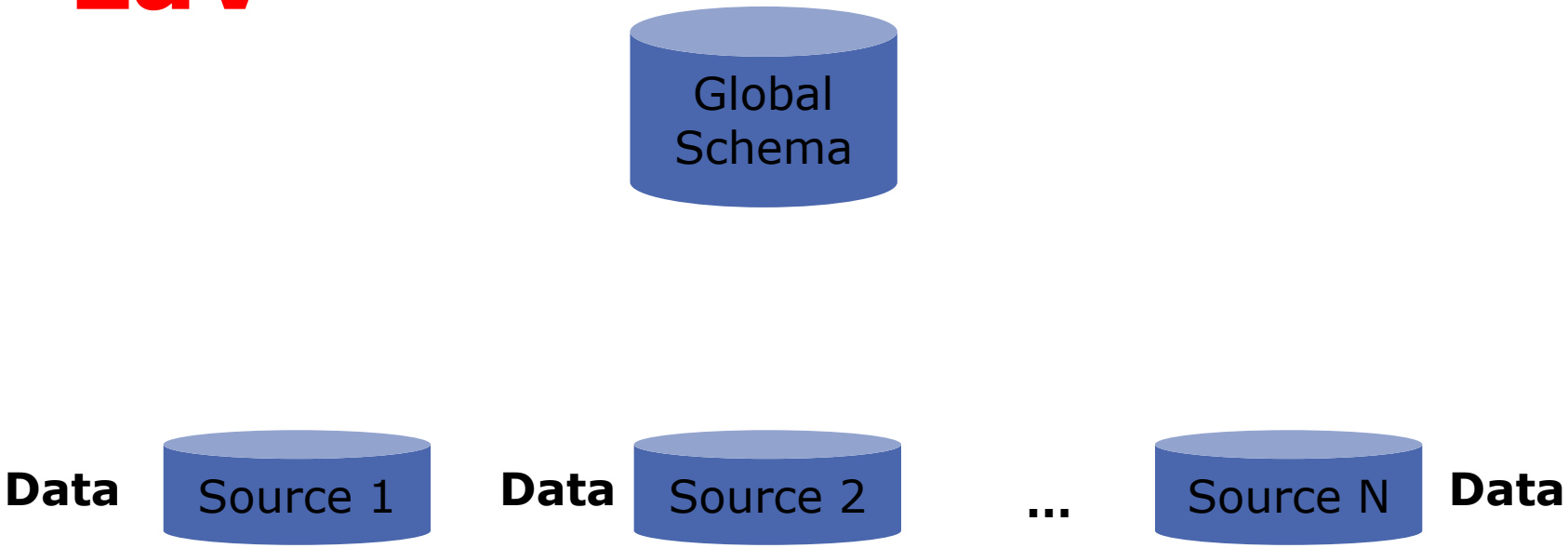
Since the GS is a view, the mappings tell us how to compute it from the sources (the mappings direction would be GS *to* sources)

~ Most basic reasoning case, rule-based

Basics on Data Integration

- Why LaV is much more complex than GaV in the general case?

LaV



Basics on Data Integration

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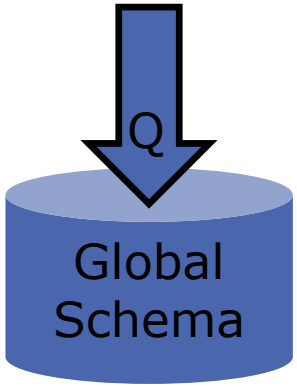
LaV



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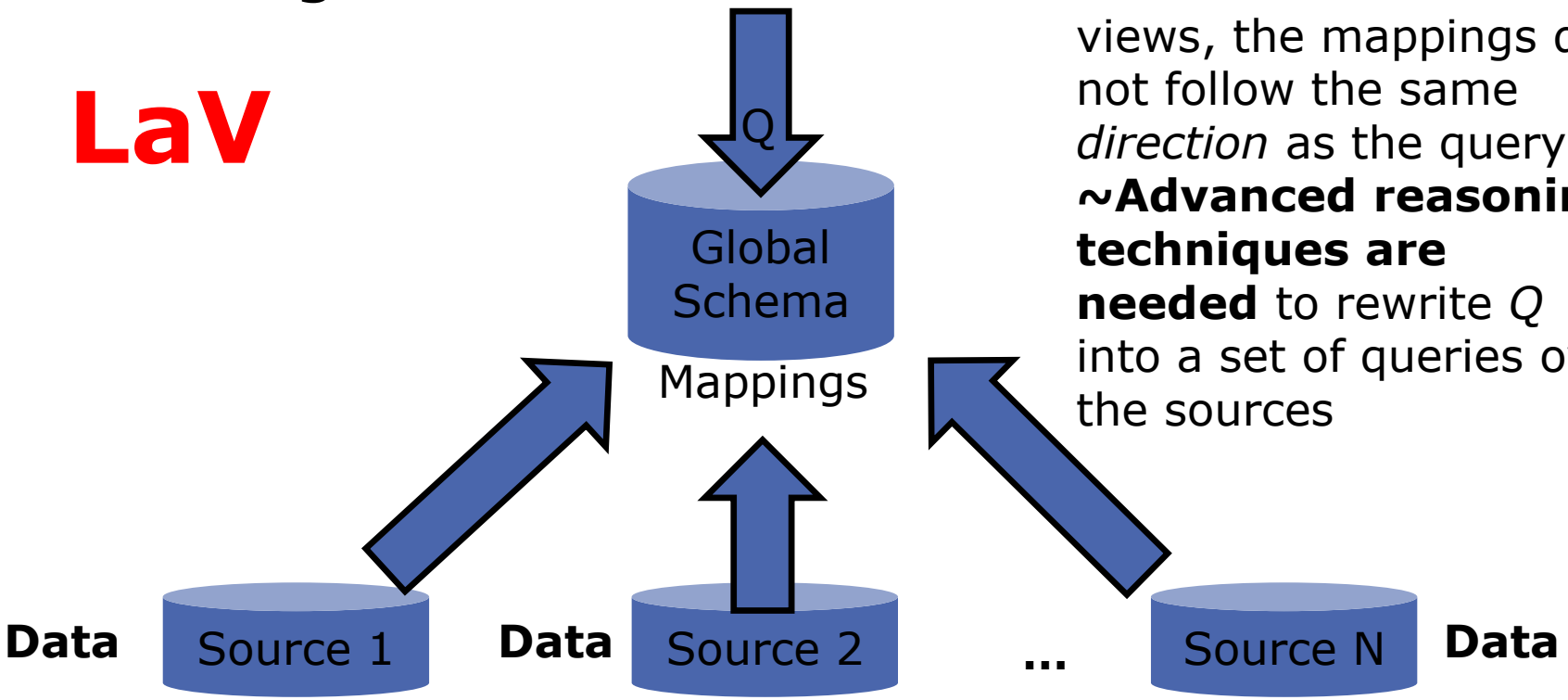
LaV



Since the sources are views, the mappings do not follow the same *direction* as the query **~Advanced reasoning techniques are needed** to rewrite *Q* into a set of queries over the sources

Basics on Data Integration

- Realise that the mappings intervene in two main stages:
  - Definition: when a source comes into the system, the mappings between the source and the global schema must be defined
  - Querying: When querying the global schema with a query Q, Q must be rewritten into a set of queries (Q_1, …, Q_n) over the data sources by using the mappings

Activity: Pros and Cons

- (15') Discuss with another peer the pros and cons of physical vs. logical integration / LAV Vs. GAV
  - (10') Understand each of them wrt the following issues:
    - Where does data reside?
    - How do the mappings look like?
    - When querying the global schema, how would query rewriting (i.e., the query execution to fetch data, process it and answer the query) look like?
    - For each case, consider:
      - How difficult is to define the mappings,
      - How difficult is the query rewriting algorithm
    - How easy would be to remove / add a new source?
  - (5') Brainstorming:
    - When is better a physical integration wrt logical integration?
    - When is better LAV than GAV? And the opposite case?

Comparison

		Materialised GS	Virtual GS	
		Static Mappings	**GaV**	**LaV**
Mapping Definition	Mapping Complexity	Very Complex	Low	Very Low
	Maintainability	Very Complex	Medium	Very Low
Querying Time	Query Rewritting	-	Simple (Unfolding)	Very Complex
	Performance	Very High	Low	Very Low

Comparison

		Materialised GS	Virtual GS	
		Static Mappings	GaV	LaV
Mapping Definition	Mapping Complexity	Very plex		Ve w
	Maintainability	Very plex	M n	Ve w
Querying Time	Query Rewritting		Si e (Un ng)	Co ex
	Performance	Ve gh		Ve w

Data Integration in Practice

- Physical Vs. Virtual Integration:
  - Physical Integration
    - AKA data consolidation
    - Querying is reduced to querying a regular database (the GS has been materialised with all the data). Thus, it goes against the autonomy of the sources which are tightly coupled
    - Freshness might be an issue
    - Examples: Data Exchange techniques, Data Warehousing
      - In the Big Data Context: Data Lake
  - Virtual Integration
    - AKA logical integration or data federation
    - Querying requires further processing as data is in the sources. GAV or LAV positioning required
    - However, data freshness is guaranteed as well as the systems autonomy (the data sources coupling is lighter)
    - The approach is less monolithic, and matches the **pay-as-you-go data integration model** blooming with Big Data
    - Examples: Federated databases (aka mediators), multidatabases
      - In the Big Data Context: Polystores, Dataframes

Data Integration in Practice

- Mappings:
  - Most systems use GaV
    - It is easier to query (unfolding)
    - Assume the sources will not vary much (mapping the sources to the GS is expensive)
  - Big Data naturally move towards LaV because:
    - Sources can leave or enter the system much easier
    - Source data is mappable to an arbitrary conjunctive query over the global schema
    - However, querying is really expensive. Two potential ways to improve this are:
      - Reducing the allowed complexity in the mappings
      - Use additional techniques to improve performance (these techniques are also used for GaV approaches)
        - Materialisation of partial results
        - Caching
        - Pre-fetching

Summary

- The Data Integration Framework
- Data Sources Layer
- Integration Layer
  - Physical Vs. Virtual integration
  - GAV Vs. LAV mappings