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Semantic Pipelines with Layered Schemas

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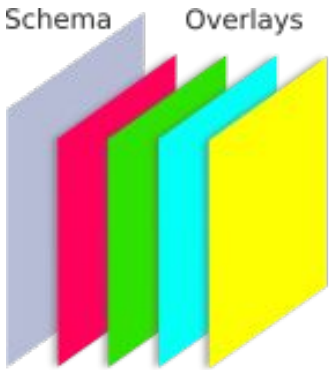
- Layered Schemas
- Semantic Pipelines
- Use-case: Vaccine Credential Generation
- Use-case: ONC LEAP: Semantic Harmonization of Health Data

Layered Schemas



Schema base defines structure

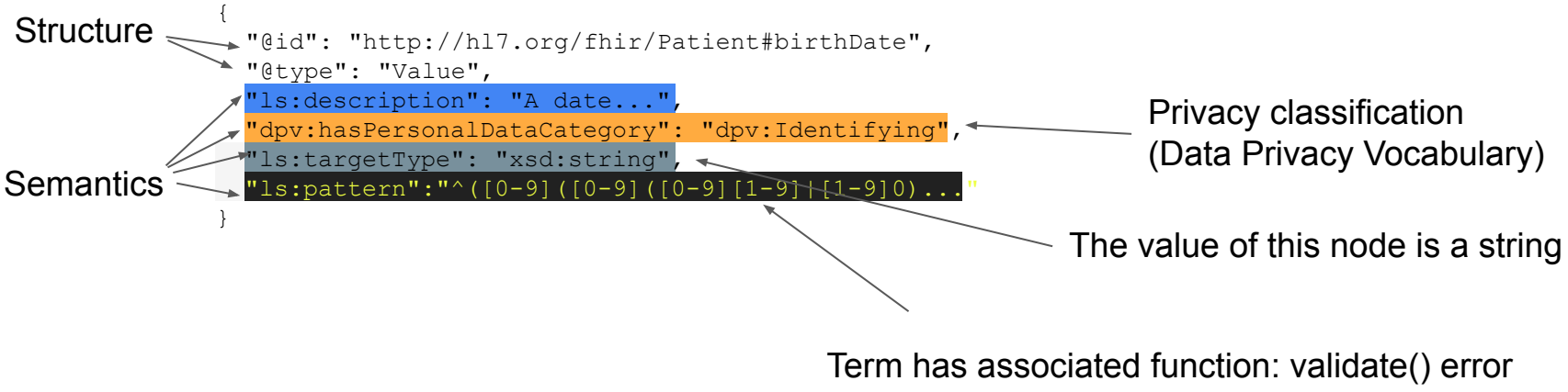
Layers add

- Constraints (min length, max value, required, etc.)
- Format (phone number, date/time, etc.)
- Language (English, Spanish, etc.)
- Dictionary/terminology references
- Privacy/security classifications (PII, Sensitive, etc.)
- Legal basis (HIPAA, consent, etc.)
- Provenance information
- Retention policies
- ...

Schema variant = Schema base + overlays

Layered Schemas: Structure + Semantics

- Metadata as layers: open-ended tags (terms, codes, identifiers)
- Metadata defines meaning **and** functionality
  - Local/jurisdictional variances, representation differences, …
- Data translated to a Labeled Property Graph guided by metadata
- Different layers → different metadata/semantics
- Different data → common graph



Schema Composition

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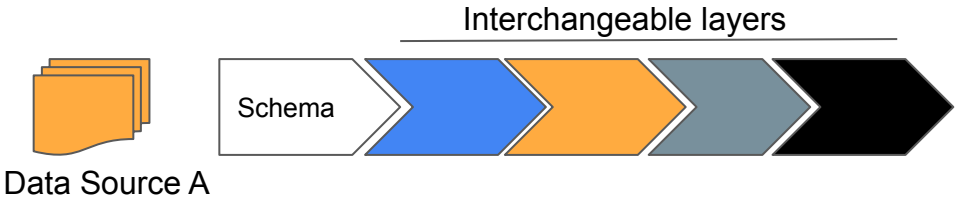
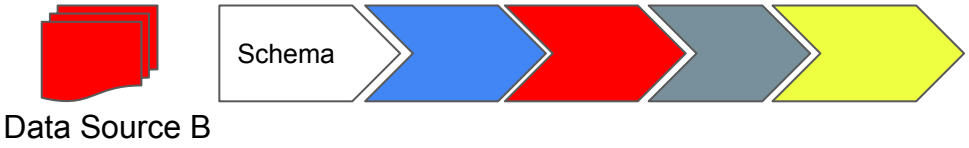
Schema defines common structure of data
Interchangeable layers account for data-source specific variations during data ingestion
Schema and layers are reusable, shareable




```
{
  "@id": "http://hl7.org/fhir/Patient#birthDate",
  "@type": "Value",
  "ls:description": "A date...",
  "dpv:hasPersonalDataCategory": "dpv:Identifying",
  "ls:targetType": "xsd:string",
  "ls:pattern":"^([0-9]([0-9]([0-9][1-9]|[1-9]0)...
}
```




```
{
  "@id": "http://hl7.org/fhir/Patient#birthDate",
  "@type": "Value",
  "ls:description": "A date...",
  "hl7:confidentiality": "M"
  "ls:targetType": "xsd:string",
  "ls:pattern":"^([0-9]([0-9])/..."
}
```

Data as Labeled Property Graphs

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JSON

```
"birthDate": "12/03/1980"
```

XML

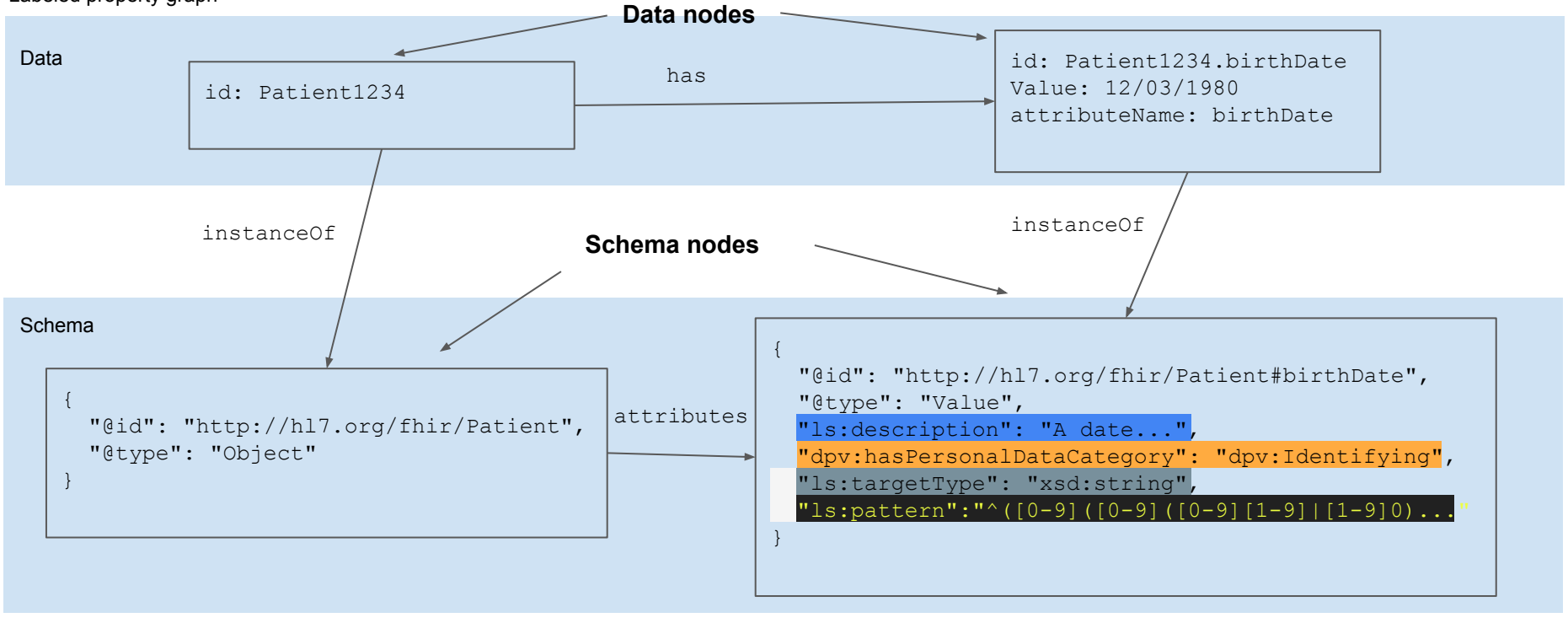
```
<birthDate>12/03/1980</birthDate>
```

CSV

```
birthDate,...
12/03/1980,...
```

Input data

Labeled property graph



Semantic Pipelines

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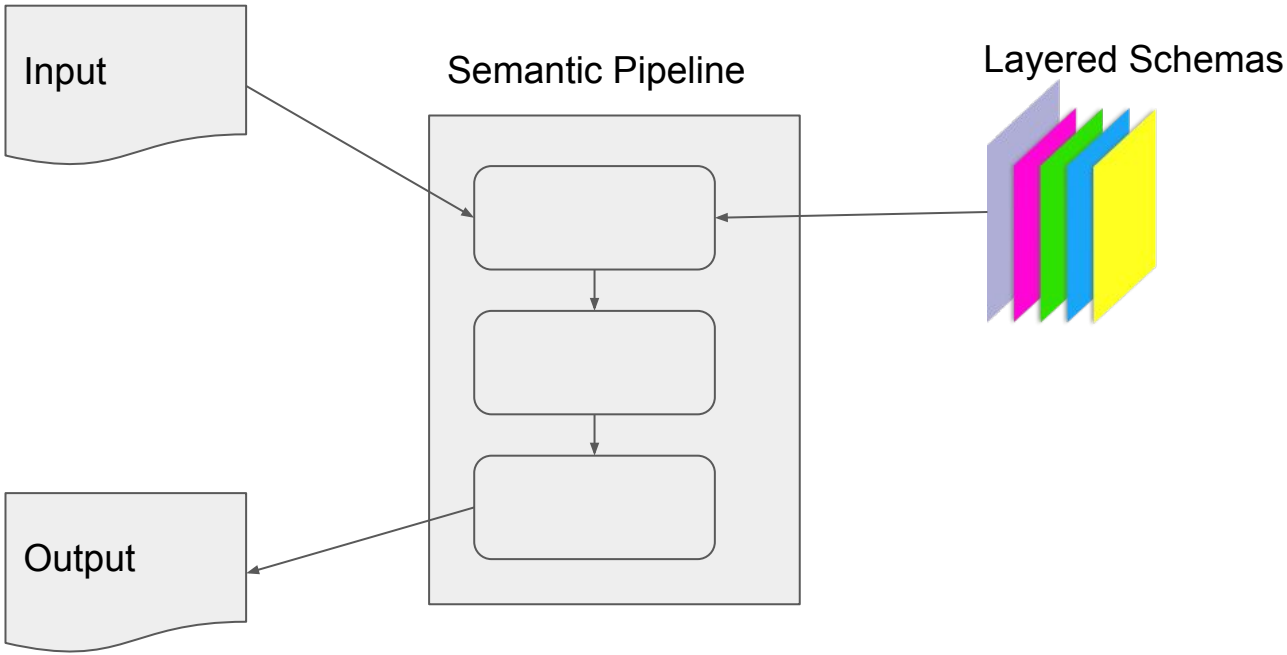

Stages: Ingest (data + schema → graph)

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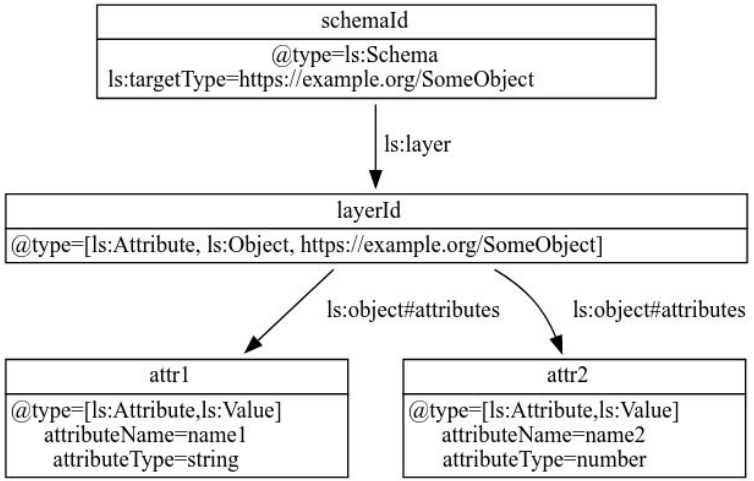
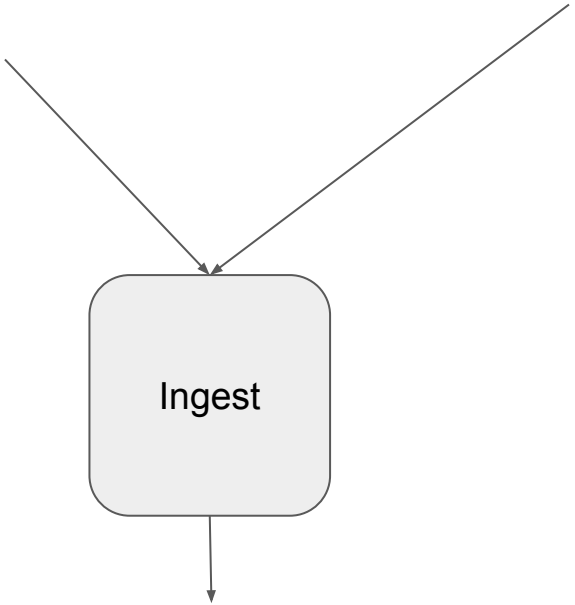
Layered Schema



Data

```
{
   "name1": "value1",
   "name2": "value2"
}
```



Stages: Ingest

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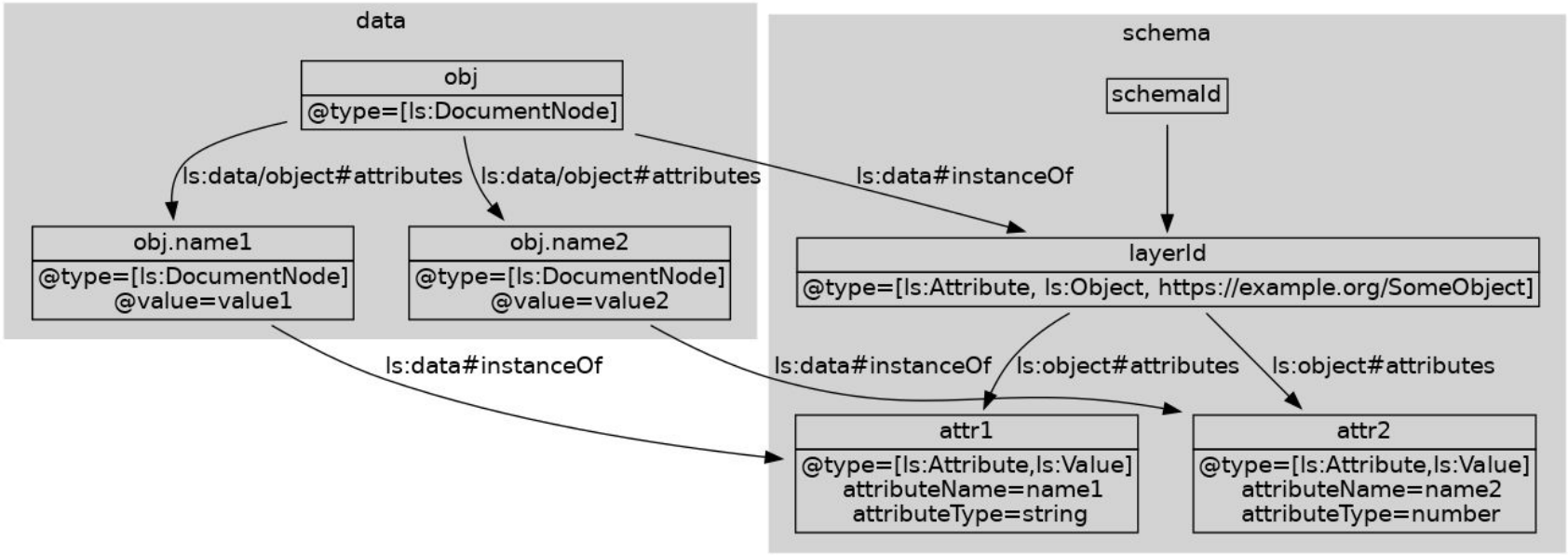

Labeled property graph with embedded schema

Stages: Reshape (graph + schema → new graph)

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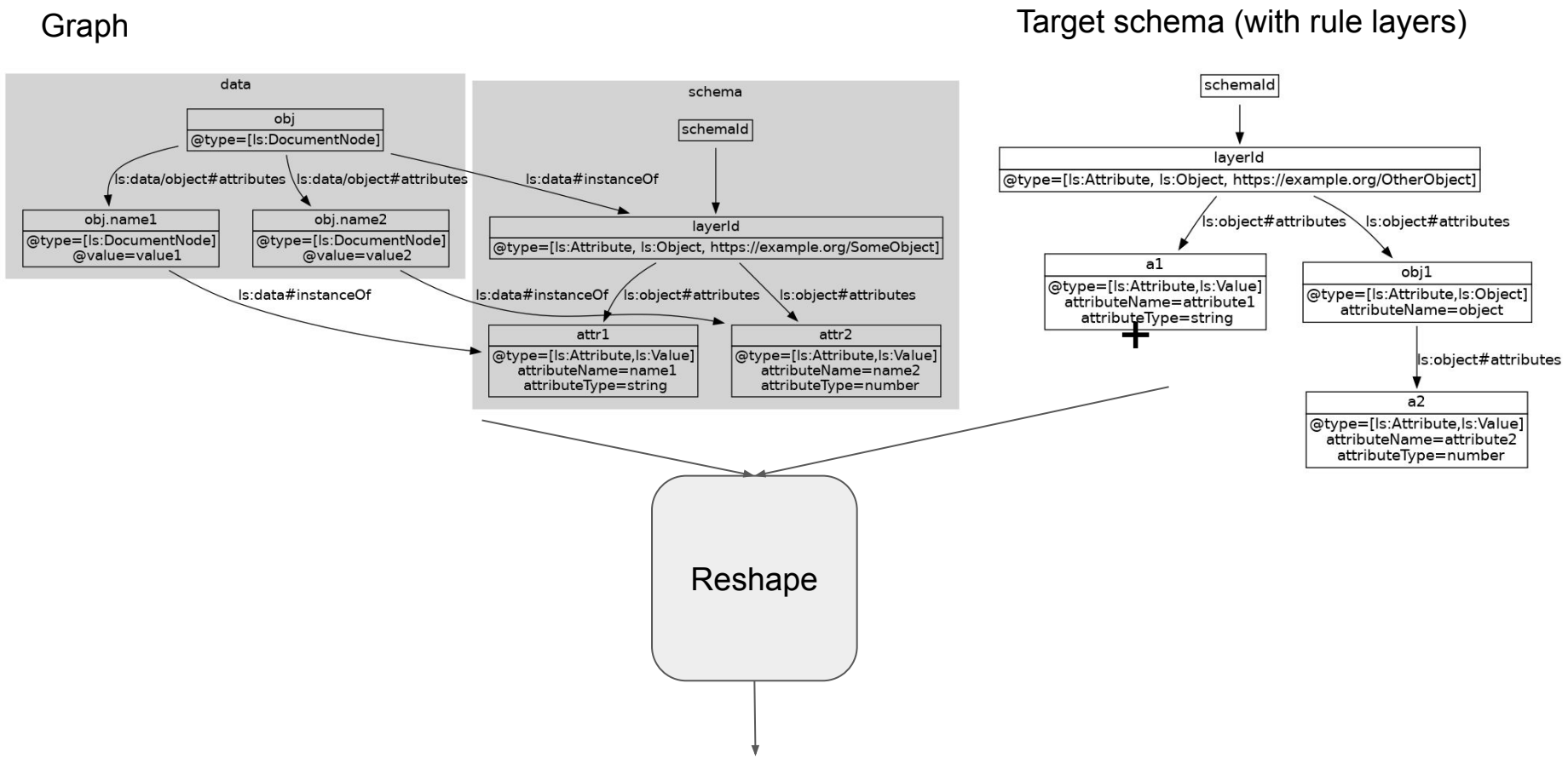

Stages: Reshape (graph + schema → new graph)

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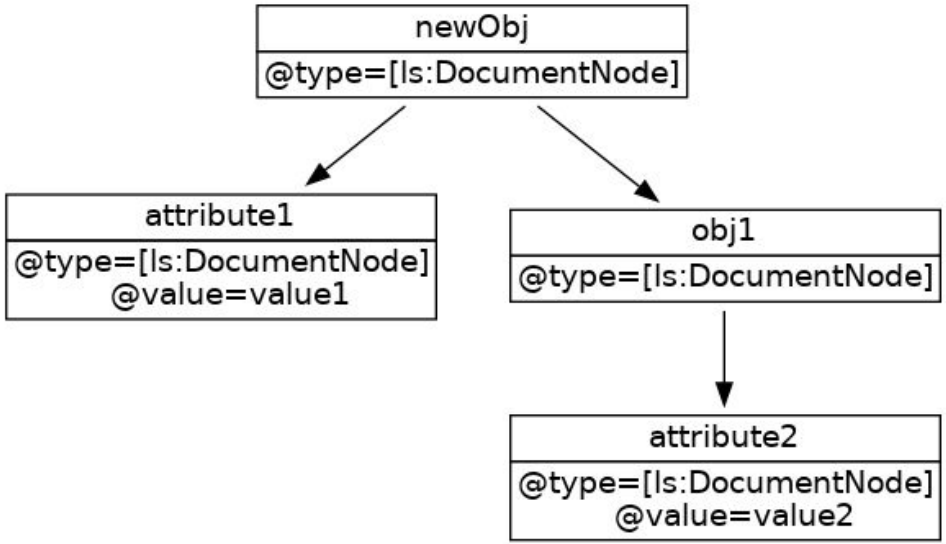


```
{
   "name1": "value1",
   "name2": "value2"
}
```

Reshape

```
{
   "attribute1": "value1",
   "obj1": {
       "attribute2": "value2"
   }
}
```

Data reshaped to conform to another schema

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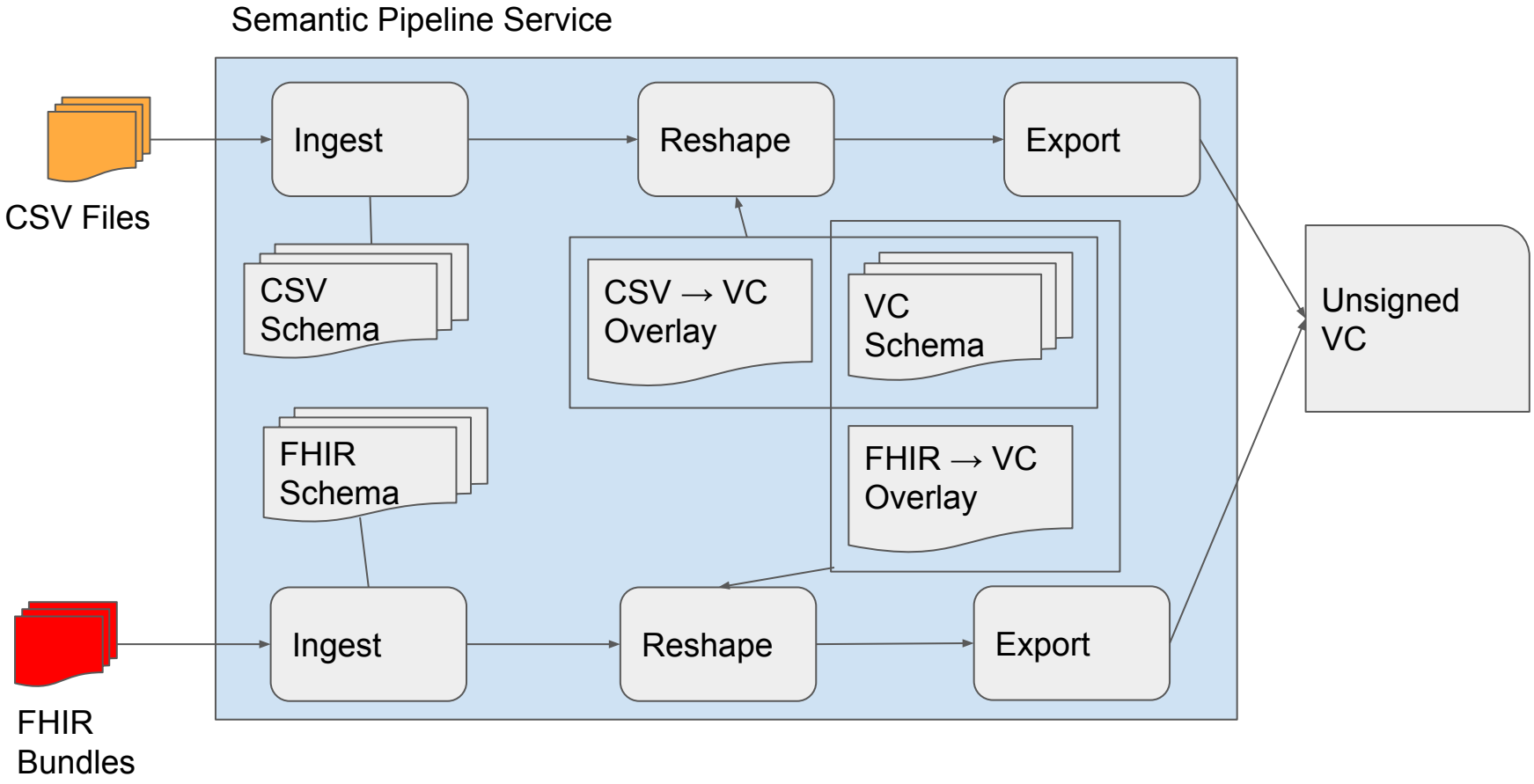
Pulse Connect Vaccine Credentials



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Use Case: A Semantic Data Warehouse for Health Data

- Collaboration with the DARTNet Institute and Cloud Privacy Labs
- Over 5000 clinical organizations contribute EHR data
- EHR data sets that cover over 30 million people
- Project Goals:
  - Replace source-specific ETL practices with a semantic pipeline based on the Layered Schema Architecture
  - Build reusable semantic mappings and components
  - Enable providers of all sizes to contribute data to a research data commons

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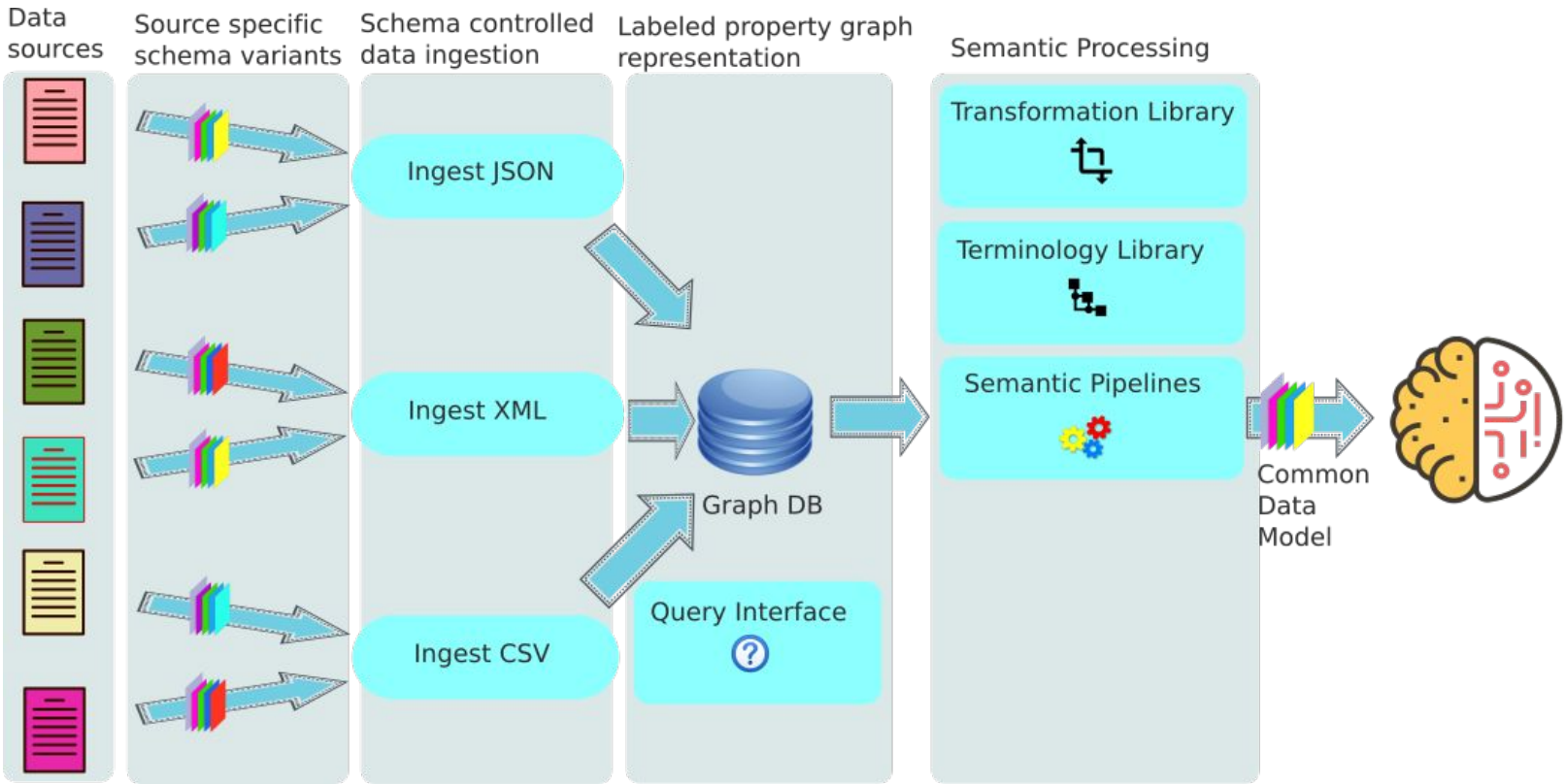

Use Case: A Semantic Data Warehouse for Health Data

Challenges:

- Values as code (2089-1) vs. text (Cholesterol in LDL [Mass/volume] in Serum)
- Same event represented in multiple tables (vaccination event as procedure and drug)
- Value sets, dictionaries: gender ("M" vs. "Male"), race ("9178" vs. "Non-white")
- Input variations (birth date as yyyy/mm vs. yyyy)
- Terminology crosswalks (LOINC, SNOMED, provider-specific codes)