

Ontology for Analytic Claims in Music (OMAC)

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General research context

Semantic Web languages, models, and technologies:

- Used to handle **musical data** on the basis of an **explicit formal** treatment of domain experts' knowledge

Web repository of SW resources for music:

- MusoW - Musical Data on the Web: <https://musow.kmi.open.ac.uk/> (by Enrico Daga et al.)

What do scholars “claim” about music?

The world of music is highly heterogeneous:

- Different **types of entities** (musical compositions, scores, editions, performances, performing requirements, composers, performers, etc.)
- Different **genres, styles, cultures, historical periods**, etc.

It is becoming common for scholars to express:

- **Features** of musical entities like who is the composer of a composition, when a composition was composed, what are its performing requirements ... but also ...
- **Observations** (aka **scholarly/analytic claims**). For example:
 - About authorship
 - About similarity
 - About date, etc.

What do scholars “claim” about music?

Claim: *An assertion* about a musical composition that is

- Made by some **person** or authority
- At a particular **time**
- In some **source** (lecture, article, book, blog . . .)
- Involving one or more **compositions** (composition's feature, performance, person, etc)
- In some cases, relating to some **portion** of the previous (certain bars, time code, etc)

Nota bene: *different* scholars can say *different* things about the *same* notes/sounds!

What do scholars “claim” about music?

Claims: will also contain some assertion relating to

- **Similarity** (does it belong to some style? some genre? is it like some other piece or passage?)
- **Structure** (what sections, forms, harmonies, melodies, or patterns are found here?)
- **Value** (is the [composition/performance] beautiful? horrible?)
- **Meaning** (what mood did it express for someone? with what extra musical ideas is it associated?)
- **Ascription** (some claim that assigns or doubts authorship, collaboration, etc.)
- **Date** (some claim that assigns or doubts a date of creation, performance, etc).
- Etc

Our work

To provide an ontology of music that represents both basic aspects of **musical entities** as well as **scholarly analytic claims** about them

In such a way to **represent** and **share** research results on [Linked Data publishing](#) platforms

→ To date, a focus on early music (pre-1600):

Development and driving insights based on: **CRIM - Citations: The Renaissance Imitation Mass Project** (ACLS grant - American Council of Learned Societies)

CRIM

Citations: The Renaissance Imitation Mass Project

<https://crimproject.org/>

Ontology for Analytic Claims in Music (OMAC)

OMAC is a Semantic Web ontology in the Web Ontology Language (OWL)

Reuse **existing resources**, e.g.:

- [Schema.org](https://schema.org/): for some classes and relations (e.g., schema:Person, schema:name)
- [Dublin Core](https://www.dublincore.org/): for annotations (e.g., dcterms:title, etc.)
- [SKOS](https://www.skos.org/): for labeling (e.g., skos:prefLabel, etc.)
- [VIAF](https://www.viaf.org/): to populate the ontology with specific musical works and composers

Available on GitHub: <https://github.com/CRIM-Project/ontop>

Competency questions (CQs) in the Context of CRIM

Some CQs driving the development of the ontology:

- Who is the **composer** of musical composition x ?
- **When** was musical composition x composed?
- Which **authorial parts** (sections and subsections) do x have (if any)?
- Which **observations** are about musical composition x ?
- What is the **model for** musical composition x ?
- What is the **derivative of** musical composition x ?
- What is the musical schema of **analytic segment** x ?

Some common
features of musical
entities

Observations (relative
to claim-classes in
CRIM)

Works and Parts of Works: ‘Authorized’ or ‘Claimed’?

Musical works often have sections and subsections defined by the composer:

- Musical Composition (a whole composition), e.g.,
 - *Missa je suis desheritée* (MJSD; by Jean Guyon) **[with sections and subsections]**
 - *Ite rime, dolenti* (Cipriano de Rore) **[with sections only]**
 - *Tota pulchra es* (by Claudin de Sermisy) **[not further divided]**
- Musical (**authorial**) **sections**, e.g.,:
 - *Kyrie_MJSD*, *Gloria_MJSD*, *Credo_MJSD*, *Sanctus_MJSD*, and *Agnus Dei_MJSD*
(customary five liturgical sections of the Ordinary of the Catholic Mass)
- Musical (**authorial**) **subsections**, e.g.,:
 - A Kyrie has three subsections: *Kyrie1_MSJD*, *Christe_MSJD*, *Kyrie_MSJD*

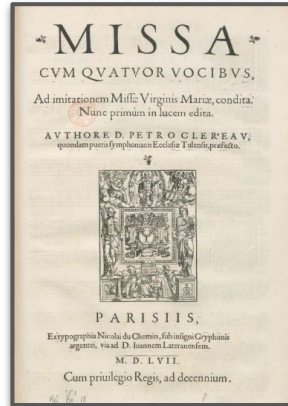
A quick note – Authorial Structure

An example from Renaissance Paris:

The **Mass** is the **Work**

The **Kyrie** is a **Movement** in the Work

The **Christe** is a **Subsection** of the Kyrie Movement



Mass

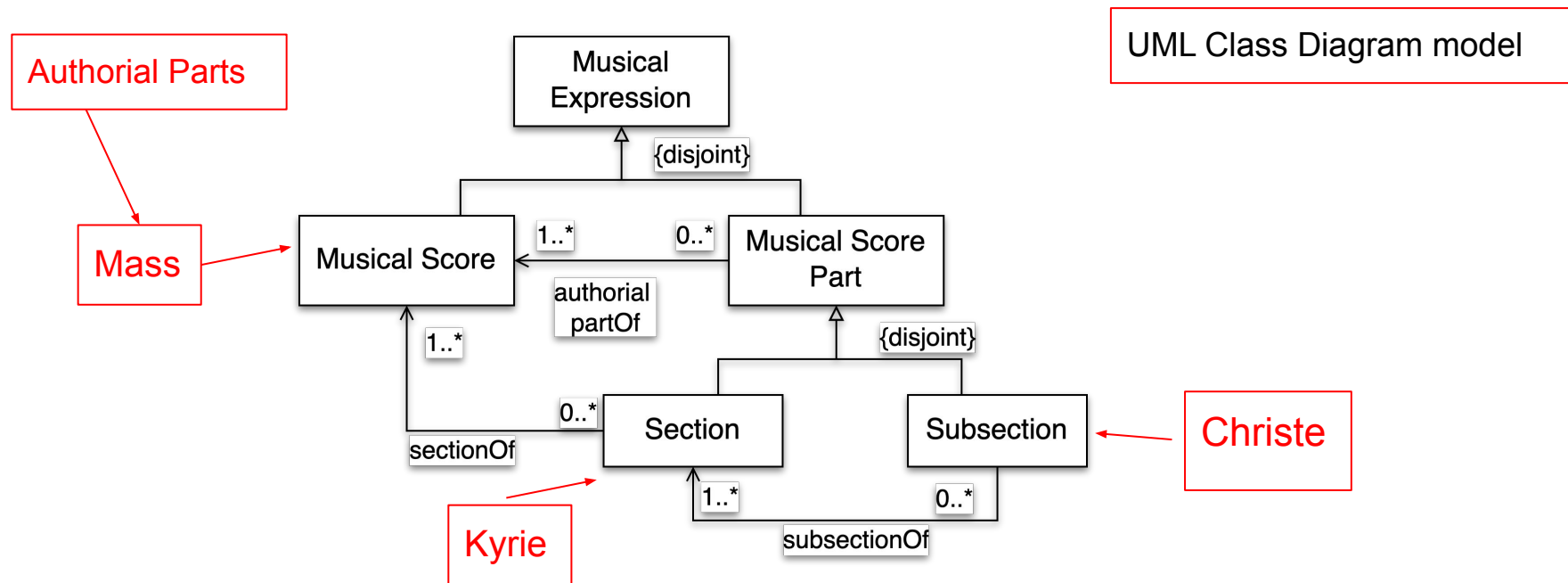


Kyrie

The image shows a page from a musical score, specifically the Christe subsection. The page number "20" is in the top left corner. The music is written on a single staff with a treble clef and a key signature of one flat (B-flat). The lyrics are written below the staff: "son. Chri - ste e - lei son. Chri - ste e - lei son. Chri - ste e - lei son. Chri - ste e - lei son." The music is written in a style typical of the Renaissance, with diamond-shaped notes and a simple, rhythmic melody. The page is numbered "20" in the top left corner.

Christe

Musical Composition - Authorial Structure



OMAC does **not** use cardinality restrictions

OWL 2 object property chains like:

- has section o has subsection → has subsection

Example of Mass from CRIM

Composition

CRIM

Citations: The Renaissance Imitation Mass Project

About ▾ Documents ▾ Analysis ▾ Forum

Missa O gente brunette [CRIM_Mass_0003]

Mass

Composer: Nicolas De Marle, 1568

Genre

Composer

Authorial Parts

Mass movements



Kyrie



Gloria



Credo



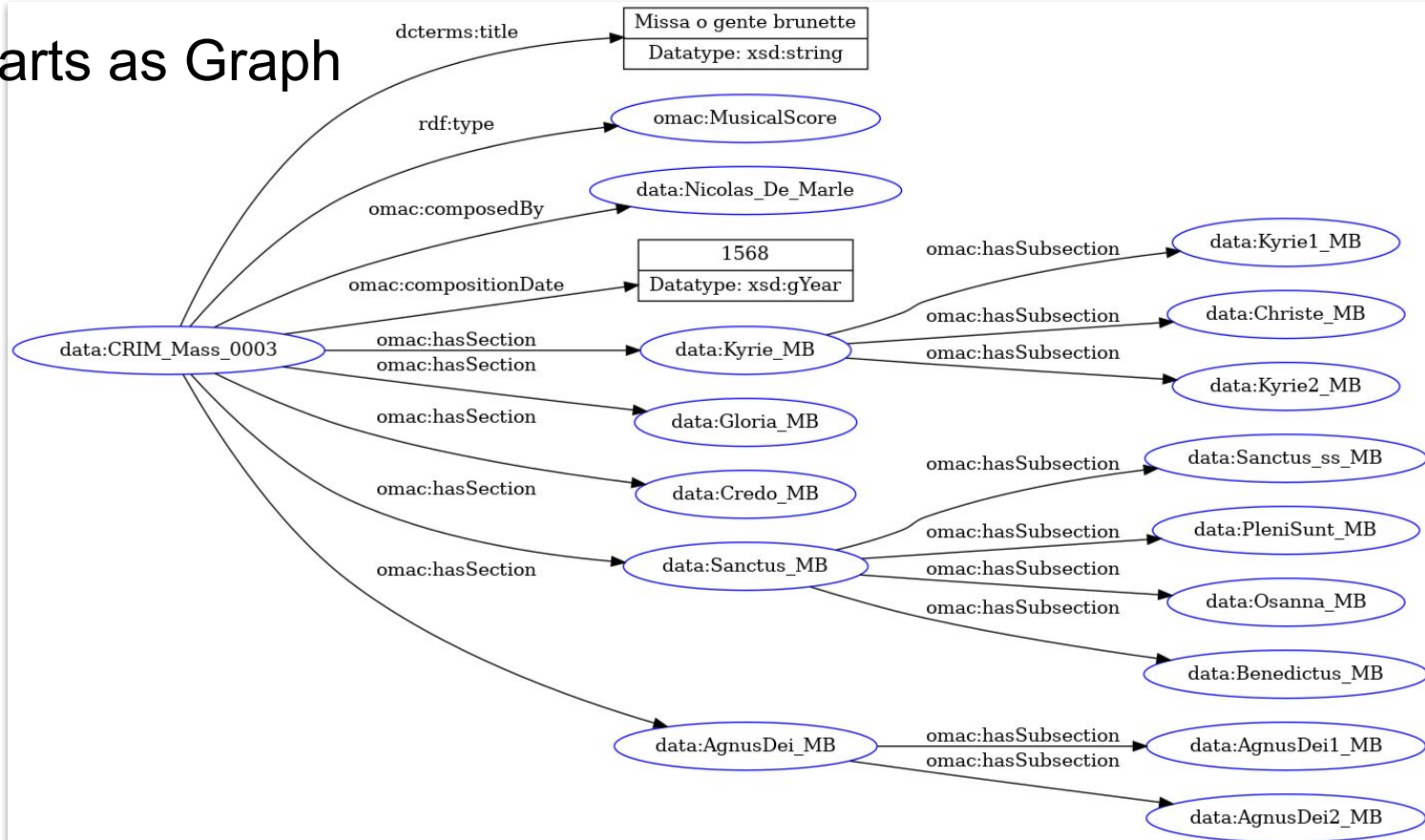
Sanctus



Agnus Dei

See: http://crimproject.org/masses/CRIM_Mass_0003/

Work and Parts as Graph



Namespaces:
data: <https://data.crimproject.org/>
omac: <https://omac.crimproject.org/>
rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
dcterms: <http://purl.org/dc/terms/>
xsd: <http://www.w3.org/2001/XMLSchema#>

Observations in CRIM

Two types of observations:

- About **structure**
- About **similarity**

For some readings, see:

- [CRIM Thesaurus of Musical Types](#)
- [CRIM Thesaurus of Relationship Types](#)

See [CRIM Essays and Experiments](#) for examples of these in action

An Observation about Structure

Anaylist

Work

Segment

Observation <622>

[Edit this observation]

[Duplicate this observation]

Observer: *Scott Troyer*

<R311> Non-mechanical transformation — Derivative of <621> O gente brunette

Score: *Missa O gente brunette: Kyrie*

< start >

Missa O gente brunette: Kyrie

Nicolas De Marle

Pattern

Periodic entry

Voices:

2: [Contratenor]

3: [Tenor]

4: [Bassus]

Entry intervals: 4-8-

Time intervals: S1

Regularity: Strict

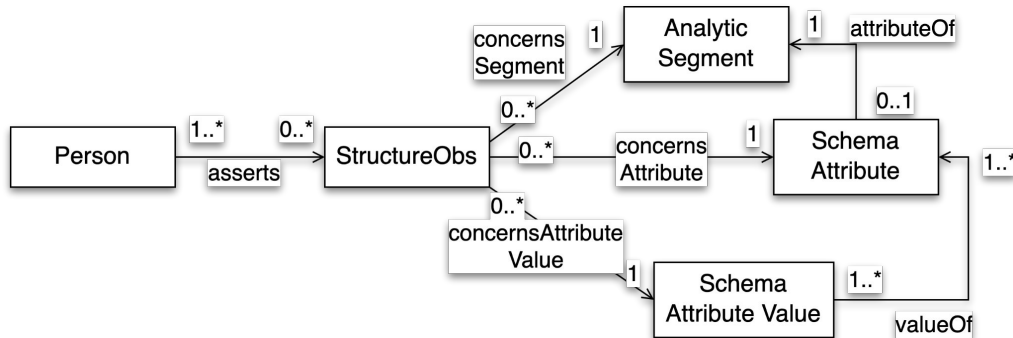
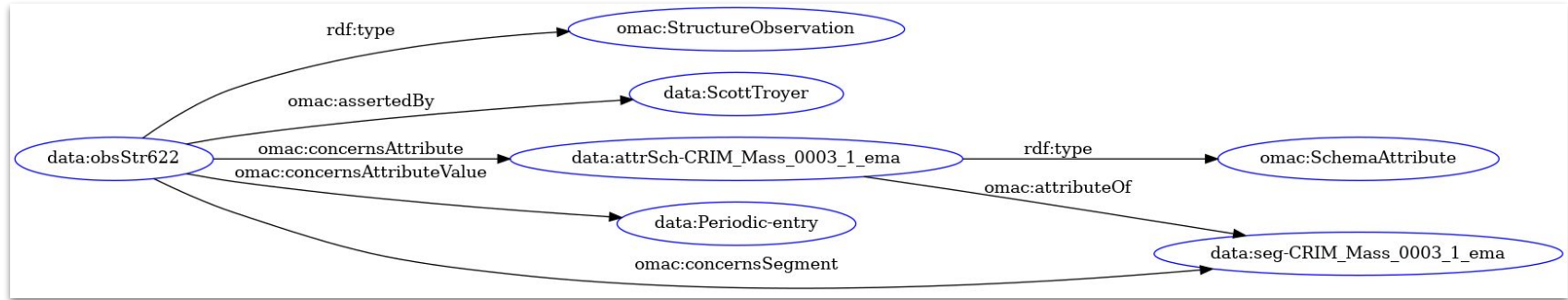
Sequential: False

Invertible counterpoint: False

Added entries: False

See data here: <https://crimproject.org/observations/622/>

In RDF (data) graph according to OMAC



The analyst assigns an attribute value to the analytic segment of a certain musical piece

Conceptual model for the graph

An Observation about Similarity

Anaylist

Relationship <R311>

[Duplicate this relationship]

Observer: *Scott Troyer*

Non-mechanical transformation

Extent: -

Activity: -

Sounding in different voices: -

Whole passage transposed: -

Whole passage metrically shifted: -

Melodically inverted: -

Retrograde: -

New counter subject: False

Old counter subject shifted metrically: True

Old counter subject transposed: True

Double or invertible counterpoint: -

New combination: False

Self: -

Model: *Thomas Champion, O gente brunette*

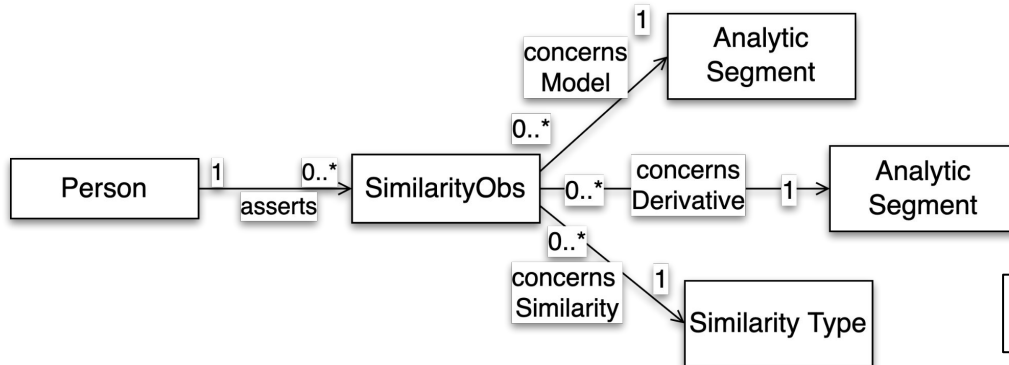
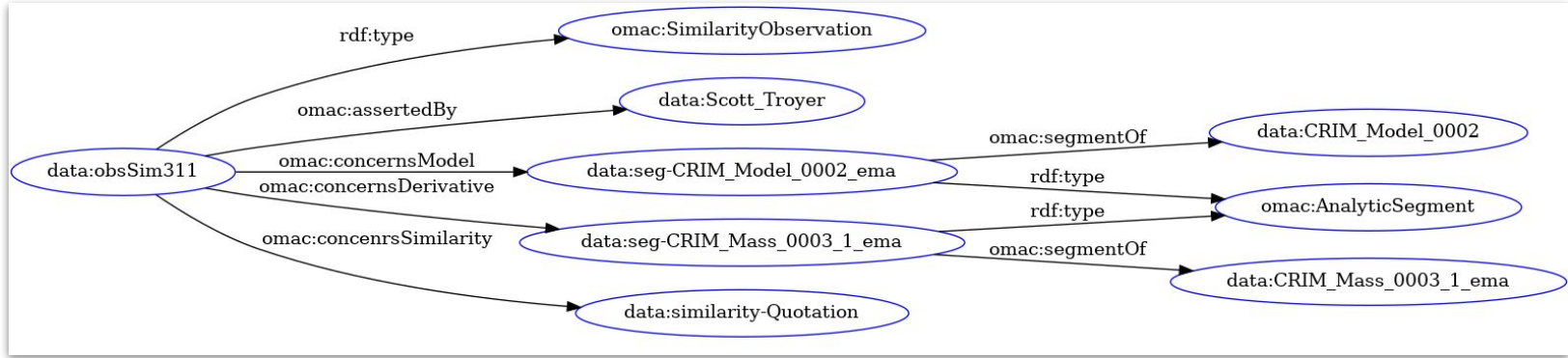
Derivative: *Missa O gente brunette: Kyrie*

Pattern

Works

See **data** here: <https://crimproject.org/relationships/311/>

In RDF (data) graph according to OMAC



Basic conceptual model for the graph

Towards a LOD application for CRIM

[OBDA](#) is an approach to link Semantic Web ontologies to relational databases (but not only) to handle the data as if it were a RDF graph

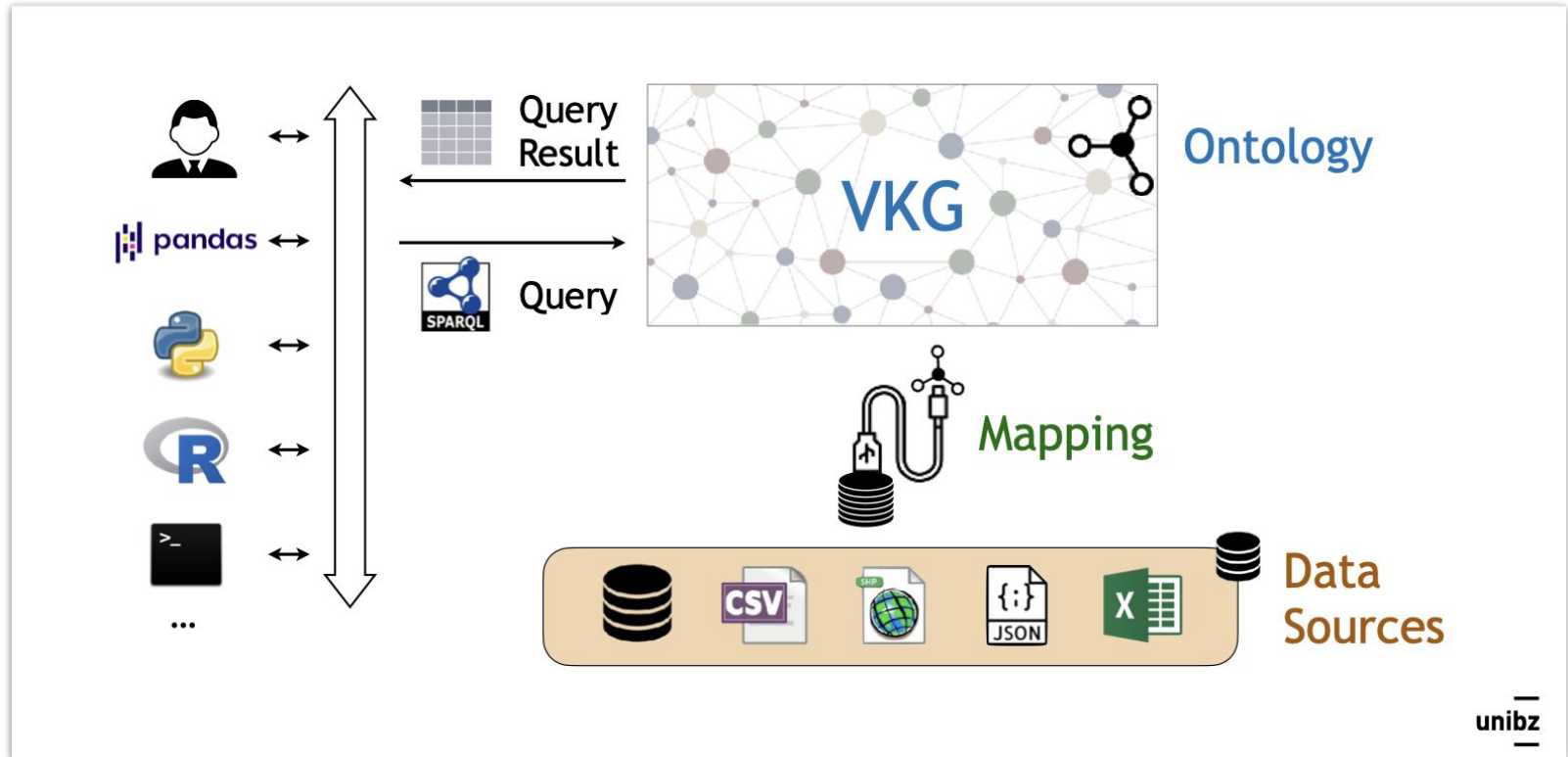
The main components of an OBDA architecture are:

- An **ontology** (OMAC in our case)
- A **data source** (the CRIM's relational DB)
- **OBDA mappings** between the ontology and the relational schema of the data source

The mappings are necessary “to translate the operations on the ontology in terms of concrete actions on the data sources”

See: De Giacomo et al (2018). Using ontologies for semantic data integration. A Comprehensive Guide Through the Italian Database Research Over the Last 25 Years, 187-202.

OBDA architecture



Credit to: Diego Calvanese (Free University of Bozen-Bolzano, Italy; [slides](#))

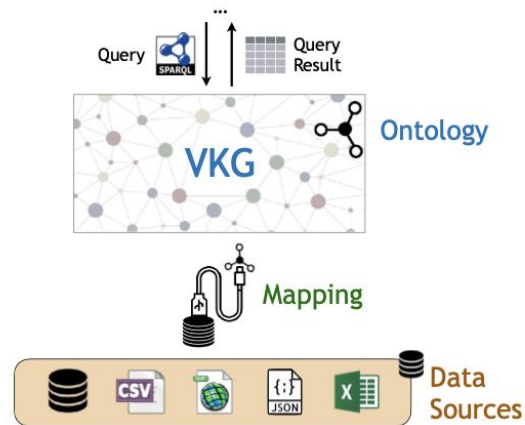
OBDA: Why? \1

Some motivations:

- Relational DB are **robust** technologies (more than 30 years experience)
- Data is **not** duplicated in different formats and different locations
- The **vocabulary** of an ontology may result more friendly to users in comparison to how data is structured across multiple relational tables
- The ontology can be used to **structure the data** at different levels of generality/specificity, as well as to enable **logical reasoning** over the data
- Through the use of Semantic Web resources, the **data can be connected** to other data (LOD, FAIR, etc.)

OBDA: Why? \2

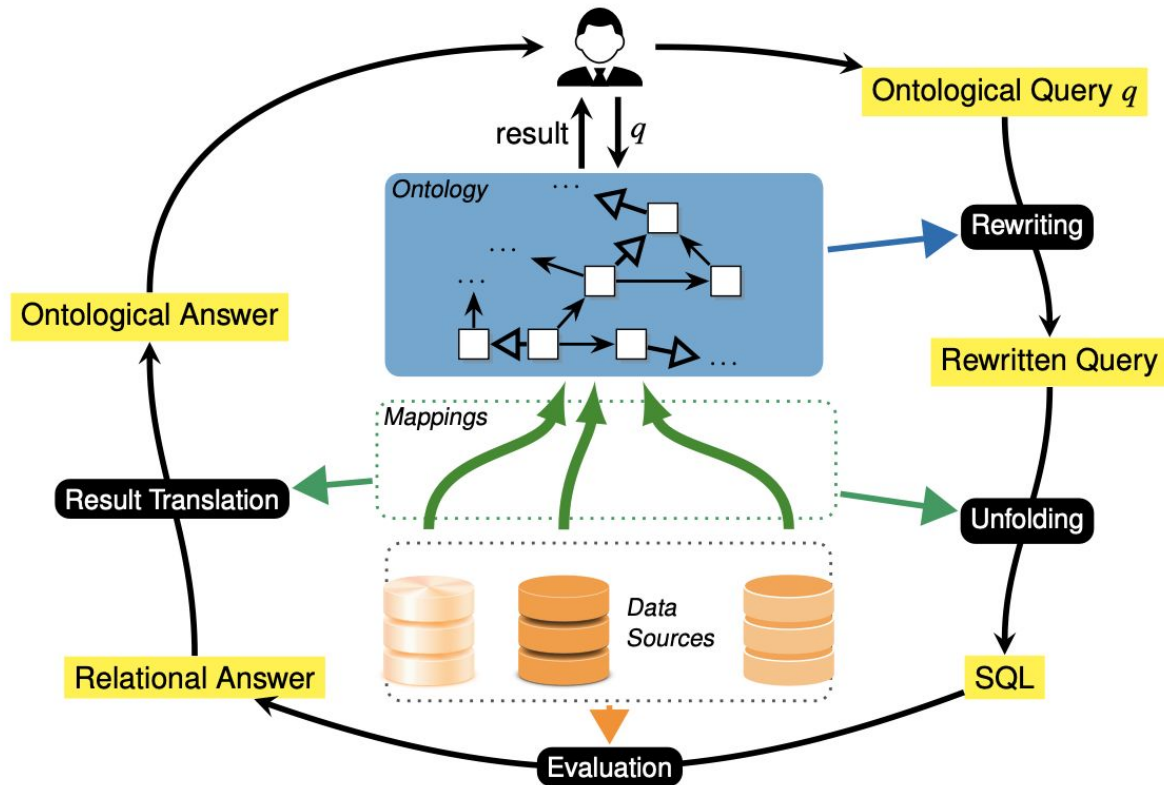
Materialized data integration relies on extract-transform-load (ETL) operations, to load data from the sources into an integrated data store / data warehouse / materialized KG.



In the **virtual approach**, instead:

- The data stays in the sources and is only accessed at query time.
- No need to construct a large and potentially costly materialized data store and keep it up-to-date.
- Hence the data is always fresh wrt the latest updates at the sources.
- One can rely on the existing data infrastructure and expertise.
- There is better support for an incremental approach to integration.

OBDA: Query-answering



OnTop - A Virtual Knowledge Graph System

An OBDA system developed by Free University of Bozen-Bolzano (Italy)

<https://ontop-vkg.org/> (open access)

- State-of-the-art VKG system.
- Implements the presented techniques for query answering and optimization.
- Addresses the key challenges of scalability and performance.
- Compliant with all relevant Semantic Web standards:
RDF, RDFS, OWL 2 QL, R2RML, SPARQL, and GeoSPARQL.
- Supports all major relational DBMSs:
Oracle, DB2, MS SQL Server, Postgres, MySQL, Teiid, Dremio, Denodo, etc.
- **Open-source** and released under Apache 2 license.

Spin-off of UniBz:
<https://ontopic.ai/en/>

Credit to: Diego Calvanese

OBDA mapping /1 (example)

Examples of data from the CRIM's database

Both tables are needed to form comprehensive RDF triples

mass_id	title	composer_id
CRIM Mass 0001	Missa Confitemini	CRIM Person 0001
CRIM Mass 0002	Missa Vidi speciosam	CRIM Person 0003
CRIM Mass 0002	Missa O gente brunette	CRIM Person 0009

Table 1 - crim_crimmass

Person_id	name
CRIM Person 0001	Pierre Colin
CRIM Person 0003	Mathieu Sohier
CRIM Person 009	Nicolas De Marle

Table 2 - crim_crimperson

OBDA mapping /2 (example)

From Table 1 to the instantiation of the data in OMAC

```
:me-{mass_id} a omac:MusicalScore;
```

```
    dct:terms:title {title};
```

[Target mapping]

```
    dbp:composer :person-{composer_id}.
```

```
← SELECT mass_id, title, composer_id FROM crim_crimmass
```

[Source mapping]

Partial view on the mapping

Example of OBDA mapping /2

From Table 2 to the instantiation of the data in OMAC

```
:person-{person_id} a schema:Person;
```

[Target mapping]

```
schema:name {name}.
```

```
← SELECT person_id, name FROM crim_crimperson
```

[Source mapping]

Partial view on the mapping

SPARQL Endpoint based on OnTop is available at:

<https://lod.crimproject.org/>

The data is exposed in a **virtual RDF graph** (it is actually in relational format)

```
1 PREFIX dbp: <http://dbpedia.org/property/>
2 PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
3 prefix dcterms: <http://purl.org/dc/terms/>
4 PREFIX schema: <https://schema.org/>
5 prefix omac: <https://omac.crimproject.org/>
6 prefix data: <https://data.crimproject.org/>
7
8 SELECT * WHERE {
9   ?person a schema:Person; schema:name ?name;
10          omac:composerOf ?composition.
11   ?composition dcterms:title ?title; dbp:genre/omac:hasValue data:genre-mass.
12 }
13
14 order by ?composition
```

Showing 1 to 50 of 50 entries (in 0.38 seconds)

Search:

Show entries

	person	name	composition	title
1	https://data.crimproject.org/person-CRIM_Person_0001	Pierre Colin	https://data.crimproject.org/me-CRIM_Mass_0001	Missa Confitemini
2	https://data.crimproject.org/person-CRIM_Person_0003	Mathieu Sohier	https://data.crimproject.org/me-CRIM_Mass_0002	Missa Vidi speciosam
3	https://data.crimproject.org/person-CRIM_Person_0009	Nicolas De Marle	https://data.crimproject.org/me-CRIM_Mass_0003	Missa O gente brunette
4	https://data.crimproject.org/person-CRIM_Person_0011	Pierre Clereau	https://data.crimproject.org/me-CRIM_Mass_0004	Missa Virginis Mariae
5	https://data.crimproject.org/person-CRIM_Person_0015	Antoine de Févin	https://data.crimproject.org/me-CRIM_Mass_0005	Missa Ave Maria

```

1 ▾ PREFIX dbp: <http://dbpedia.org/property/>
2 PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
3 prefix dcterms: <http://purl.org/dc/terms/>
4 PREFIX schema: <https://schema.org/>
5 prefix omac: <https://omac.crimproject.org/>
6 prefix data: <https://data.crimproject.org/>
7
8 ▾ construct {
9     ?person a schema:Person; schema:name ?name;
10             omac:composerOf ?composition.
11     ?composition dcterms:title ?title; dbp:genre ?genre.
12     ?genre omac:hasValue data:genre-mass.
13 ▾ } WHERE {
14     ?person a schema:Person; schema:name ?name;
15             omac:composerOf ?composition.
16     ?composition dcterms:title ?title; dbp:genre ?genre.
17     ?genre omac:hasValue data:genre-mass.
18

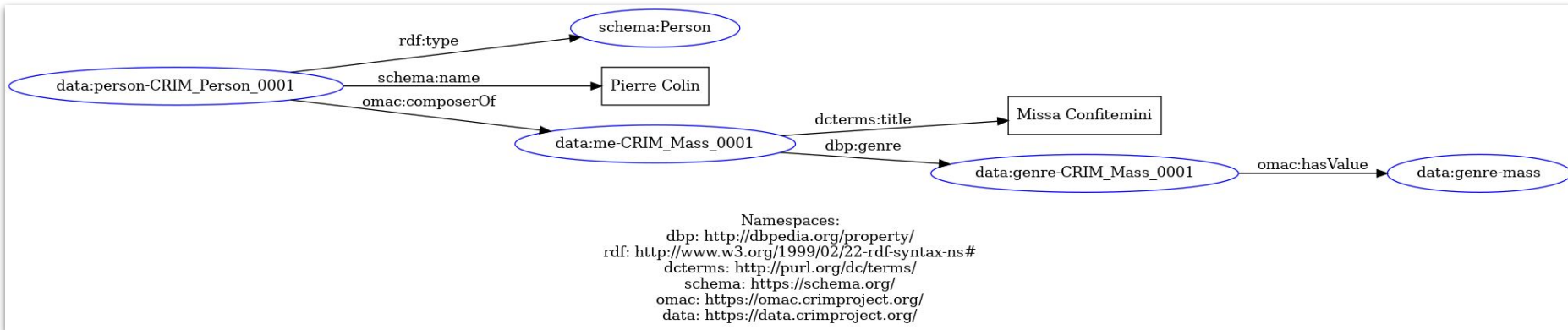
```

```

1 @prefix dbp: <http://dbpedia.org/property/> .
2 @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
3 @prefix dcterms: <http://purl.org/dc/terms/> .
4 @prefix schema: <https://schema.org/> .
5 @prefix omac: <https://omac.crimproject.org/> .
6 @prefix data: <https://data.crimproject.org/> .
7 @prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
8 @prefix rdf4j: <http://rdf4j.org/schema/rdf4j#> .
9 @prefix sesame: <http://www.openrdf.org/schema/sesame#> .
10 @prefix owl: <http://www.w3.org/2002/07/owl#> .
11 @prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
12 @prefix fn: <http://www.w3.org/2005/xpath-functions#> .
13
14 data:person-CRIM_Person_0001 a schema:Person;
15     schema:name "Pierre Colin";
16     omac:composerOf data:me-CRIM_Mass_0001 .
17
18 data:me-CRIM_Mass_0001 dcterms:title "Missa Confitemini";
19     dbp:genre data:genre-CRIM_Mass_0001 .
20
21 data:genre-CRIM_Mass_0001 omac:hasValue data:genre-mass .
22
23 data:person-CRIM_Person_0003 a schema:Person;
24     schema:name "Mathieu Sohier";
25     omac:composerOf data:me-CRIM_Mass_0002 .
26
27 data:me-CRIM_Mass_0002 dcterms:title "Missa Vidi speciosam";
28     dbp:genre data:genre-CRIM_Mass_0002 .
29
30 data:genre-CRIM_Mass_0002 omac:hasValue data:genre-mass .

```

The data can be **materialized** in
RDF, e.g., with SPARQL
CONSTRUCT queries



RDF graph for the mass
CRIM_Mass_0001

More information

To see more on the backstage of the application (e.g., mappings):

- <https://github.com/CRIM-Project/ontop>

Work is required to improve user experience, possibly get more data from the CRIM's DB, etc.

Thank you!

For info, comments, and suggestions please write to:

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