ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

SCHOOL OF INFORMATION SCIENCES & TECHNOLOGY | MSc in Information Systems

Master Thesis

Big Civic Data Management And Analysis : The case of Athens

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Case study

Cities are an ideal test environment for data integration because of the multitude and heterogeneity of their data

Athens is the capital of Greece and a potential metropolitan center

Issues examined during the implementation of the project

- Technological approaches to improving city operations
- Data processing (datasets)
  - *Understanding (real) data*
  - *Data Cleaning*
- Principles of designing databases
  - *Normalization*
  - *Database schemas*

Issues examined during the implementation of the project

- Creating a virtual database
  - *Connections to underlying databases*
- Design and use of ontologies
  - *Classes, object properties, data properties*
- R2RML: RDB to RDF Mapping Language
- SPARQL query language

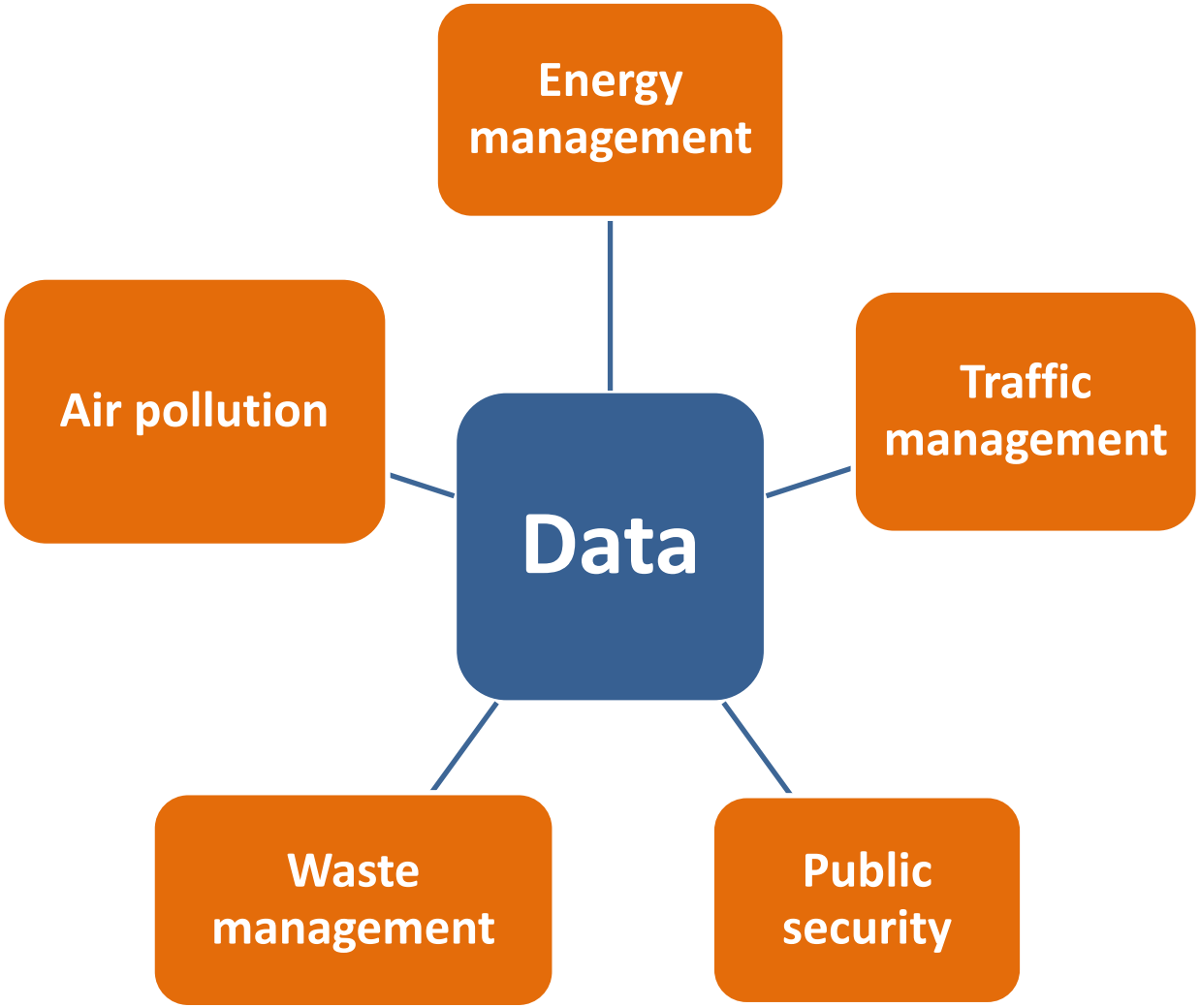
Project structure

Implementation

- Datasets (broken down by category)
- Creating databases
- Creating a virtual database
- System architecture
- Creating an ontology of the city of Athens
- Creating ontology mappings with databases
- Run questions in ontology

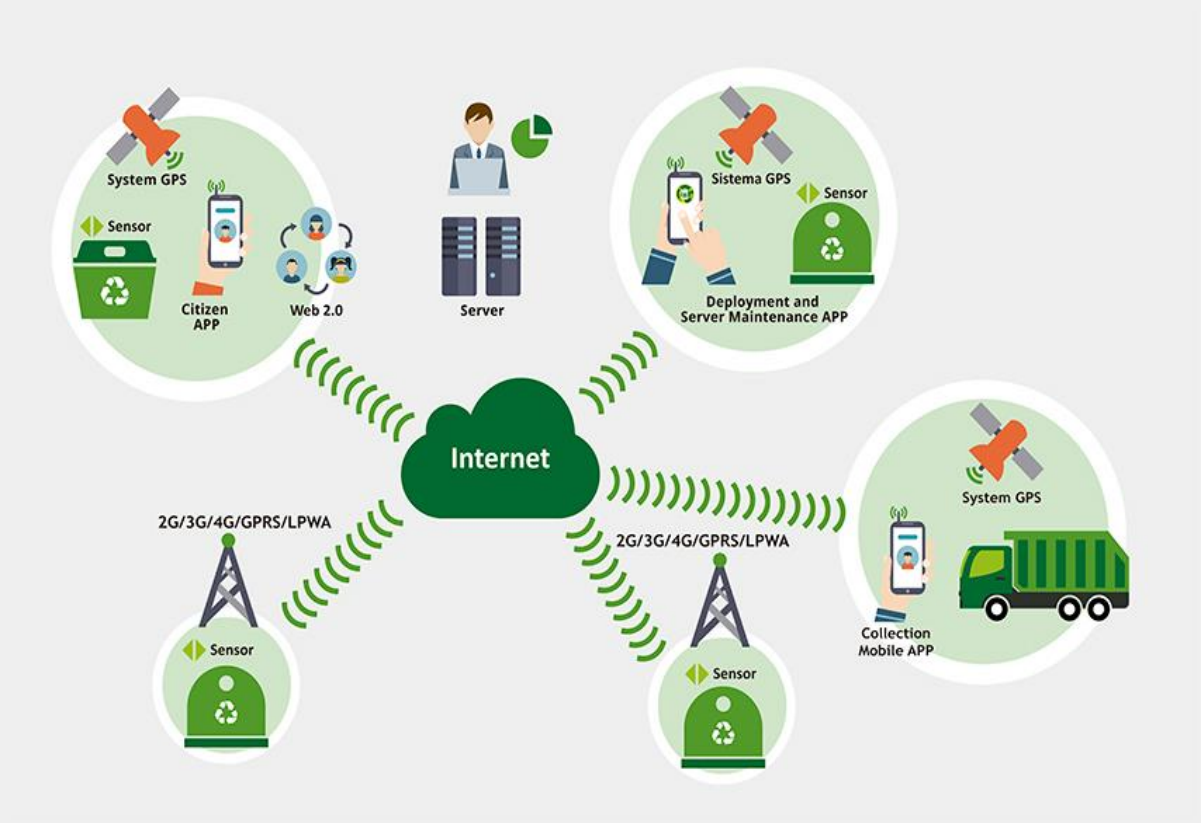
Cities and data

Big cities operations



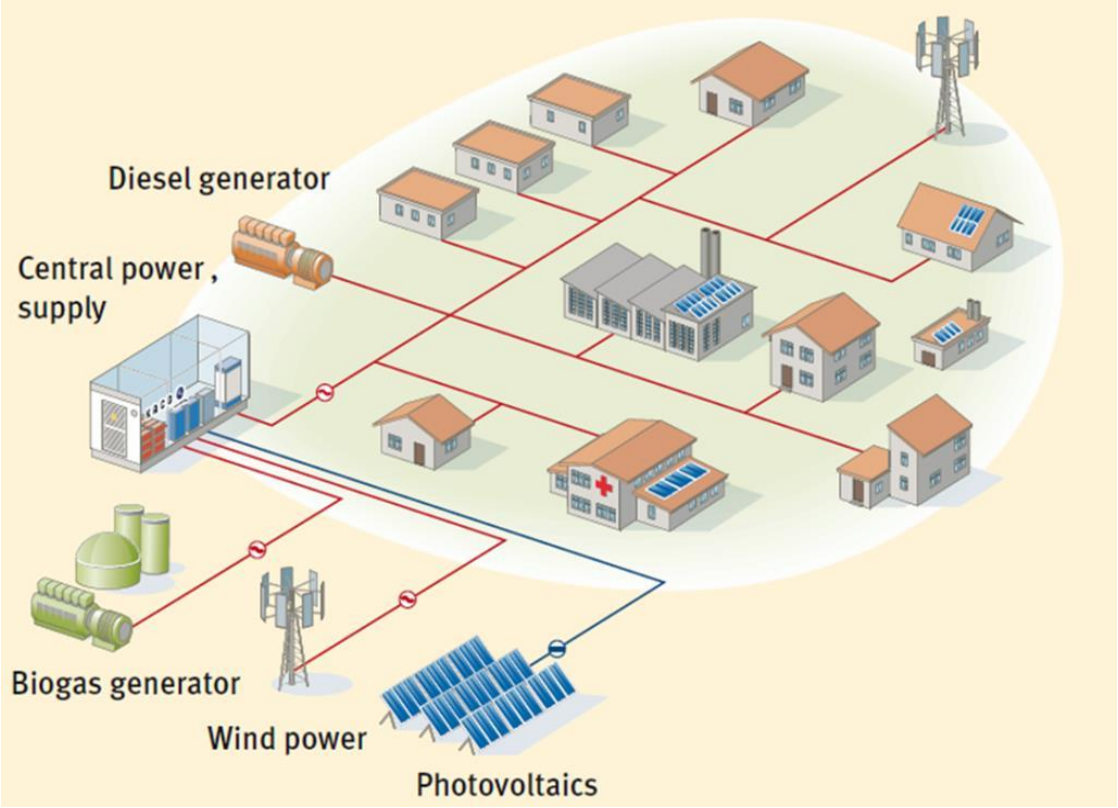
Waste management

- Waste level sensors
- Optimization of routes
- Design of waste management policies



Energy management

- Distributed and dynamic network
- Energy footprint
- Demand model recognition
- Dynamic pricing policy with personalized savings recommendations



Traffic management

- Traffic jam
- Parking
- Car movement analysis
- Air pollution issues

City's data characteristics

Large volume

Heterogeneity

Increasing frequency

BIG DATA

Cities and Big Data
(The challenge)

- **BIG DATA management**
  - “Cleaning”
  - Integration
- **Process BIG DATA in (near) real time**
- **Exploitation of BIG DATA**
  - Decision making
  - Live information (city residents, guests)

Other data sources for cities

OPEN DATA

- A rich source of information combining many areas of interest
- Available at no cost
- High degree of differentiation
  - Structured, unstructured
  - Machine readable
  - Linked

Main Technology Approaches to Data Integration

Why do we care about Data Integration in cities?

Especially in cities :

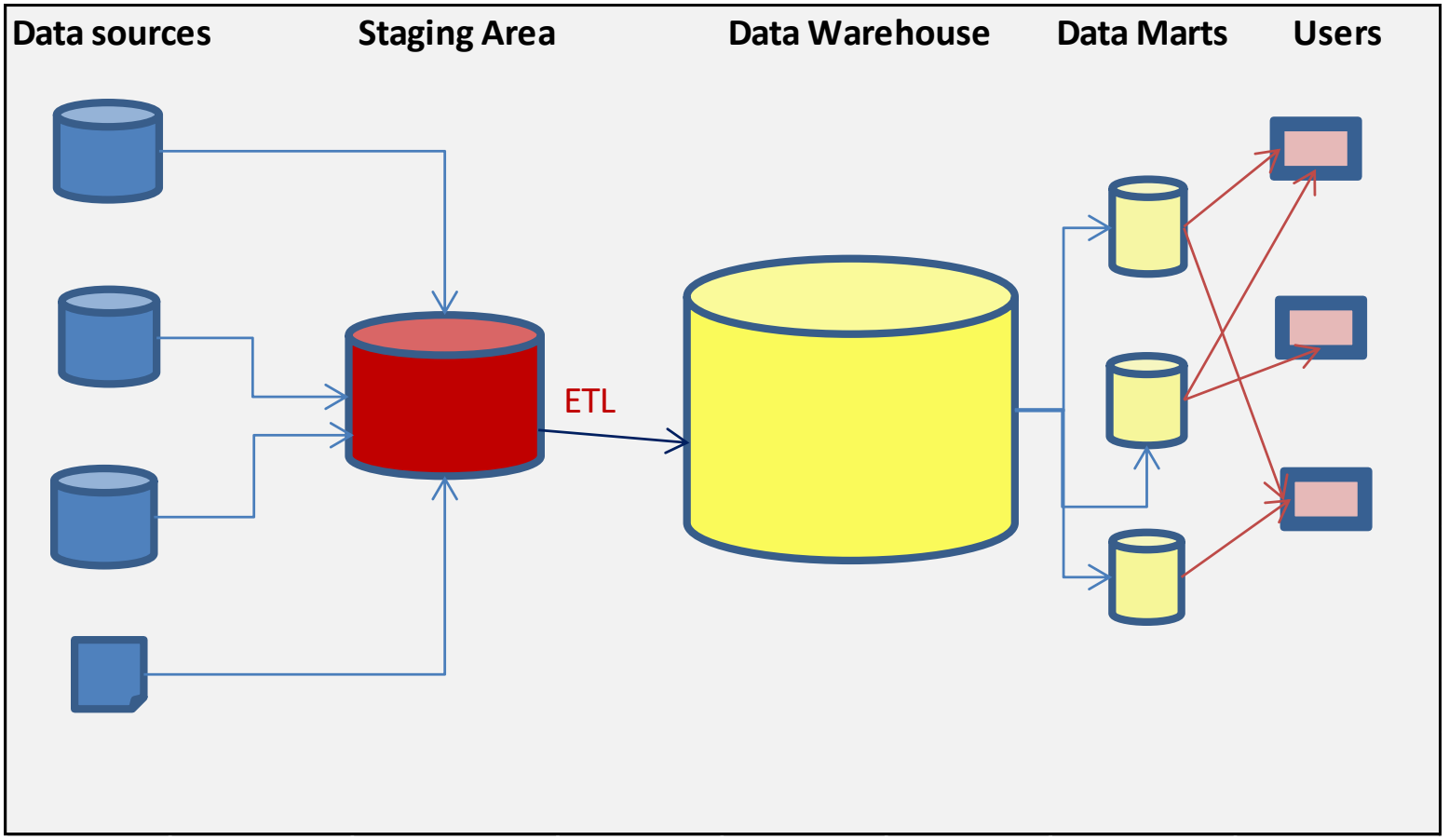
- Many data sources
- The information is stored in silos
- Common content data
- Non linked data (not in context)
- An interdisciplinary approach to complex problems is required

Main Technology Approaches to Data Integration

- Data Warehouse
- Virtual Database
- Ontology – based Data Access (OBDA)

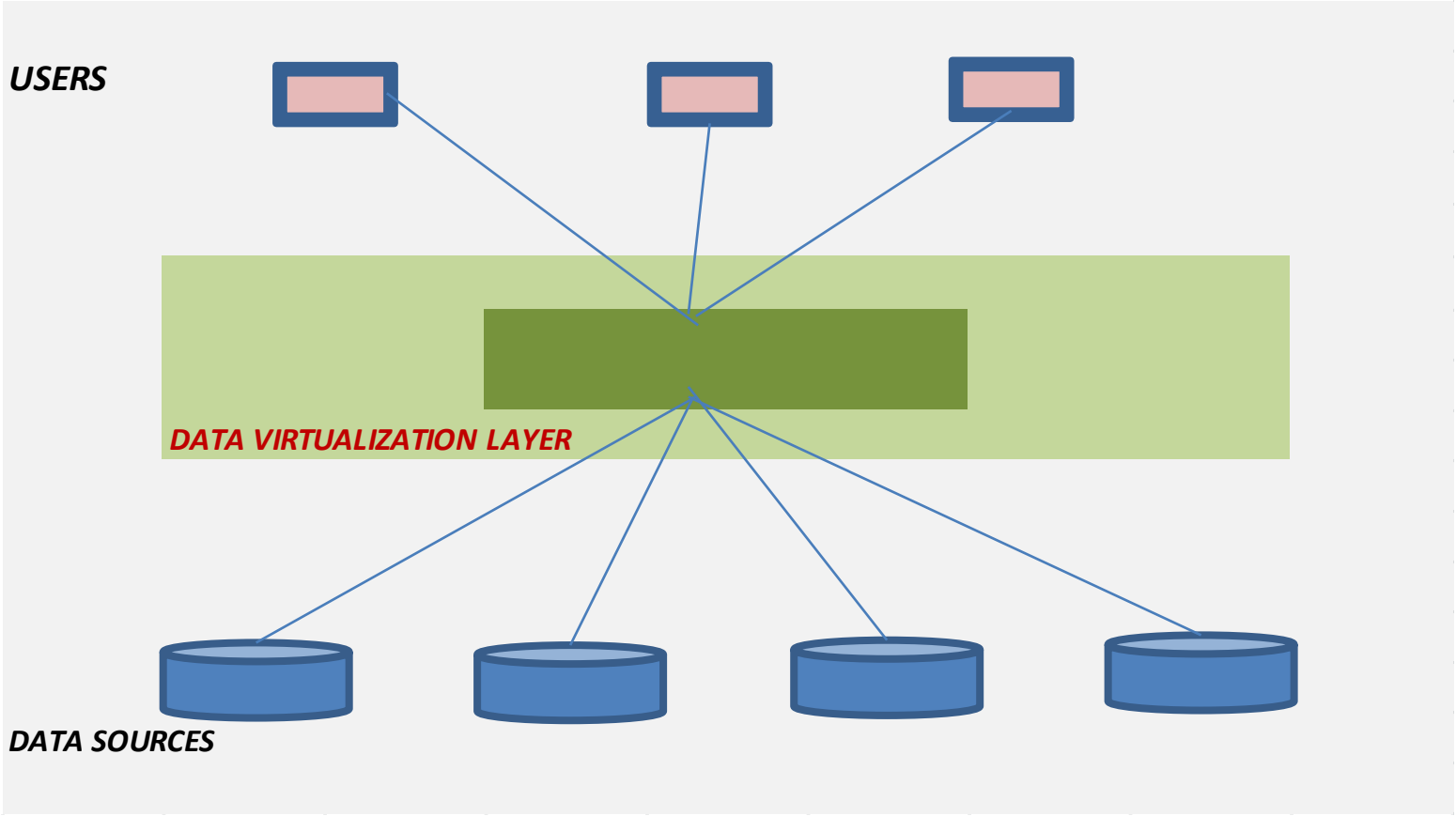
Data Warehouse

The basic architecture of a Data Warehouse solution includes:



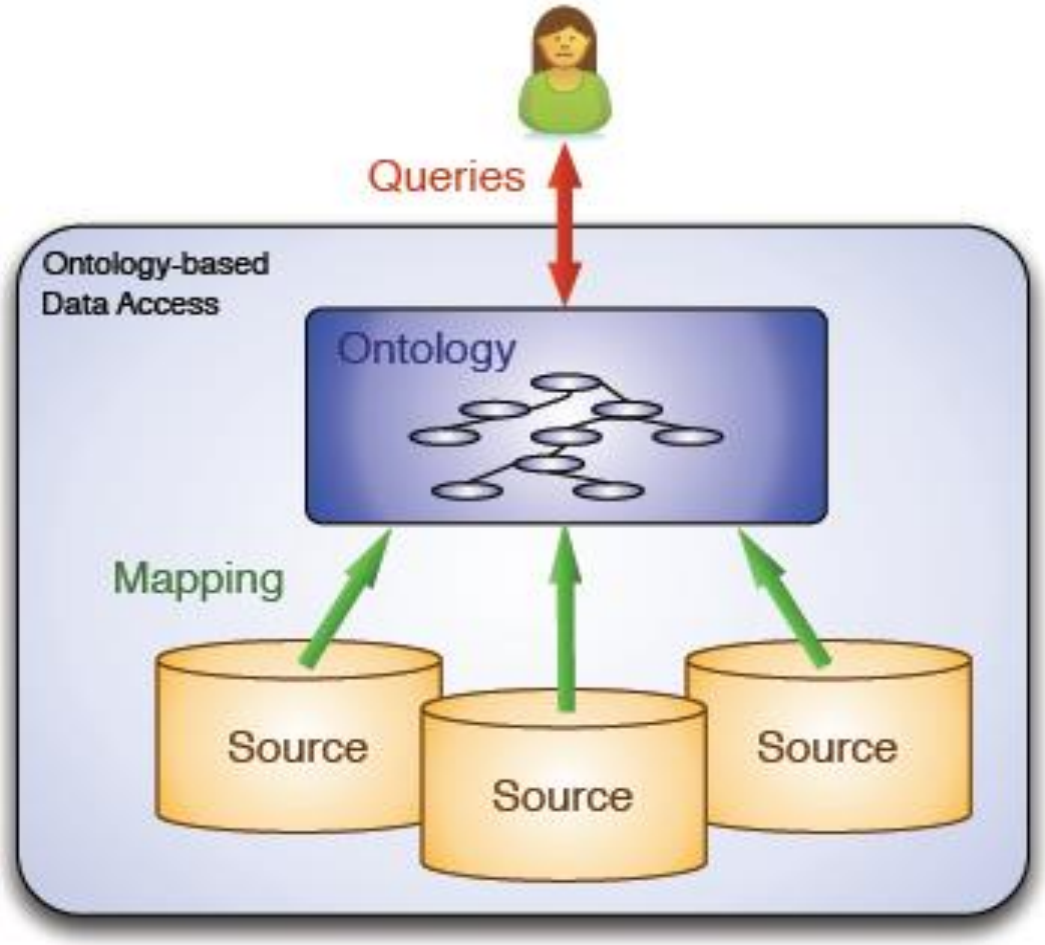
DATA INTEGRATION
Virtual Database

The data remains in their physical location



Ontology-Based Data Access

Main components of the OBDA architecture



- **Target ontology**
- **Mappings**

  They connect semantically the ontology with the data

- **Databases**

  External, heterogeneous, multiple

Data Integration Approaches (comparative analysis)

Data warehouse	Data integration	OBDA
Advantages	**Advantages**	**Advantages**
Large amount of data and historical data	The data remains in the local sources	Queries are performed on explicit and commonly accepted concepts of ontology
Speed	Access to real-time data	The documentation of ontology and mappings with local data sources is supported by the reasoner function
Data cubes and roll up, drill down, pivot operations	Virtual database techniques are not expensive	Ease of Scalability
"Back up" of the local databases	Ease of Scalability	The data remains in the local sources(*)
	Data reliability	Access to real-time data (*)
Disadvantages	**Disadvantages**	**Disadvantages**
Tough and time consuming ETLs	Lack of historical data. Time series depend on local sources	"Hard to understand" ontology concepts by non experts
Difficult scalability	Local sources must be constantly online	Difficulty in creating ontology and mappings
Hardware and software cost	Performance issues in "consuming" queries	Possible performance issues in "bad" ontology design and mappings
No access during the update procedure	Queries run on demand. An additional layer is required to handle queries	Lack of historical data. Time series depend on local sources
		Local sources must be constantly online (*)
** On the fly implementation*		

IMPLEMENTATION

Datasets
(characteristics)

Dataset description / Dataset elements	TYPE OF FILE	NUMBER OF LINES	NUMBER OF COLUM	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
GIS_city lighting	.shp	≈ 8300	73	fid,N,10,0	id_i,C,254	x,C,254	y,C,254
GIS_waste bins (underground)	.shp	≈ 2100	11	id,N,10,0	OBJECTID,N,20,0	ID_1,N,24,15	PER_POP,N,24,1
GIS_waste bins (real)	.shp	≈ 2100	9	x	y	id	area_en
GIS_hotels, cinemas, museums	.shp	≈ 500	27	fid,N,10,0	id,N,10,0	name,C,254	status,C,1
GIS_theatres (real)	.shp	≈ 106	4	fid	eponymia	perigrafi	dieuthinsi
GIS_schools	.shp	≈ 236	21	fid,N,10,0	status,C,1	score,N,10,0	match_type,C,2
GIS_historic center limits	.shp	≈ 1	6	fid,N,10,0	area,N,24,15	perimeter,N,24,	istoriko_,N,20,0
GIS_city's agencies	.shp	≈ 100	13	fid,N,10,0	id,C,254	yphresies,C,254	type,C,254
urban fault reporting (complaints)	.csv	≈ 12000	10	AIT_ID	AIT_DATETIME	AST_PERIGRAFH	AIT_COMMENTS
municipal waste collection	.xls	≈ 3000	4	A/A	programma	odoi	arithmos kadwn
municipal police	.csv	≈ 1.057.000	11	PARK_YEAR	PARK_VRN	KLS_DESCR	PARK_ARKLHSHS
municipal human resources	.xls	≈ 5.000	10	A/A	ΚΛΑΔΟΣ	ΘΕΣΗ	ΔΙΕΥΘΥΝΣΗ
swimming pool payments	.xls	≈ 5.305	8	Πρόγραμμα	Κοιν. Ομάδα	Ηλ. Ομάδα	Φύλο
swimming pool people	.xls	≈ 2.572	7	BarCode	Φυλο	Δήμοτης Δ. Αθηνών	Κοιν. Ομάδα
swimming pool uses	.xls	≈ 21.530	8	Κοιν. Ομάδα	Ηλ. Ομάδα	Φύλο	Εντός Δ.Α
air pollution	.dat	≈ 15.000	5	aerio	perioxi	imerominia	ora
Number of properties per building and street	.csv	≈ 78.084	5	Οδός	Αριθμός	Τύπος Ακινήτου	Σχέδιο
price zone per street	.csv	≈ 105.864	9	Έτος	Οδός	Από (Περιττοί)	Έως (Περιττοί)
weather data athens gazi	.txt	≈ 1.000	13	DAY	MEAN TEMP	HIGH	TIME
financial	.xls	≈ 9.000	13	Μήνας	Δήμος	2η Βαθμίδα	Περιγραφή 2ης Βαθμίδας
financial	.xls	≈ 4.100	8	Μήνας	Δήμος	Περιγραφή 3ης Βαθμίδας	Διαμορφωμένος ΠΥ
cultural events							
sports							
toyrism							
traffic							
social media							
public transportation (bus lines and line stops)							

Datasets
(Issues) (1)

Basic findings

Glossary (terminology) differences

For the description of the address, at least 5 different fields are used in the datasets obtained. Also, latitude and longitude are used

street
odos
onom_odou
dieuthinsi
periohistreet

x
y
gmikos
gplatos

Datasets
(Issues) (2)

Basic findings

Semantic differences

The common values of the relevant fields are not sure to refer to the same areas. It had to be investigated with the agency that provided the data.

periohi
dimotikienotita
area_gr
periohiperigrafi

Datasets
(Issues) (3)

Basic findings

Descriptions of the database fields

No standard or more general naming rules are applied to the tables and database fields. Apart from the ambiguity of the values entered in the relevant fields of the tables (3 different databases in the example), no specific protocol is implemented (eg capital letters, small dashes, etc.)

AW_PERIGRAFH
YPH_NAME
KLS_DESCR
KLC_DESCR
apoper
eosper

Datasets
(Issues) (4)

Basic findings

Problems in values describing the same entity

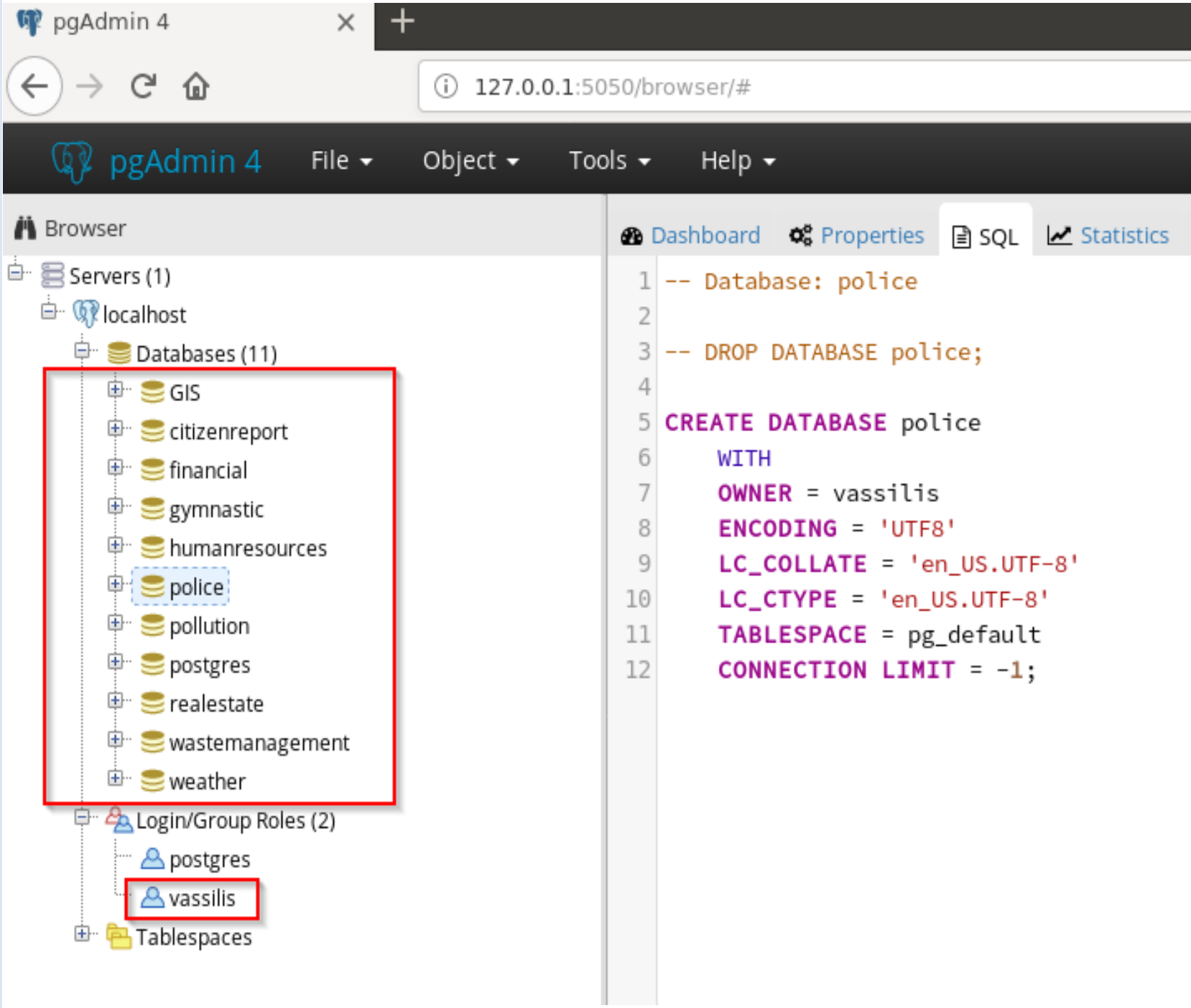
dataset	values
prosopiko_idax	26. Δ/ΝΣΗ ΚΑΘΑΡΙΟΤΗΤΑΣ-ΑΝΑΚΥΚΛΩΣΗΣ
prosopiko_idax	15. Δ/ΝΣΗ ΚΟΙΝΩΝΙΚΗΣ ΑΛΛΗΛΕΓΓΥΗΣ ΚΑΙ ΥΓΕΙΑΣ
prosopiko_monimoi	Δ-ΝΣΗ ΚΑΘΑΡΙΟΤΗΤΑΣ-ΑΝΑΚΥΚΛΩΣΗΣ
prosopiko_monimoi	Δ-ΝΣΗ ΚΟΙΝΩΝΙΚΗΣ ΑΛΛΗΛΕΓΓΥΗΣ & ΥΓΕΙΑΣ
e-request	Δ/ΝΣΗ ΚΑΘΑΡΙΟΤΗΤΑΣ - ΑΝΑΚΥΚΛΩΣΗΣ
e-request	Δ/ΝΣΗ ΚΟΙΝΩΝΙΚΗΣ ΑΛΛΗΛΕΓΓΥΗΣ & ΥΓΕΙΑΣ

dataset	values	
police	periohistreet	periohistreetnum
police	3ΗΣ ΣΕΠΤΕΜΒΡΙΟΥ	10
police	3ΗΣ ΣΕΠΤΕΜΒΡΙΟΥ	10
police	3ΗΣ ΣΕΠΤΕΜΒΡΙΟΥ	10
e-request	street	
e-request	3ΗΣ ΣΕΠΤΕΜΒΡΙΟΥ 10	
e-request	3ΗΣ ΣΕΠΤΕΜΒΡΙΟΥ 10	
e-request	3ΗΣ ΣΕΠΤΕΜΒΡΙΟΥ 10	

Databases creation
(Main points)

- **Database software**
  - PostgreSQL version 9.5
  - pgAdmin4 version 3.0 – PostgreSQL management tool
- **Nine(9) databases**
  - Exclusively using datasets and other data recorded in meetings with database administrators and business users.
  - The databases are independent of each other with a high degree of heterogeneity of data.
  - Especially for the project, they "run" on the same server

Databases creation (screenshot)



Databases creation
(Main tasks)

Table normalization

- Database schema creation

  It was not made available by any organization

- Primary and foreign keys
- Operation of null values
- Determining the "correct" datatype, "cleaning" and adjusting values wherever possible

Virtual database creation
(key implementation points)

Restrictions of the OBDA framework used

(connect ontology only to one database)

Installation required :

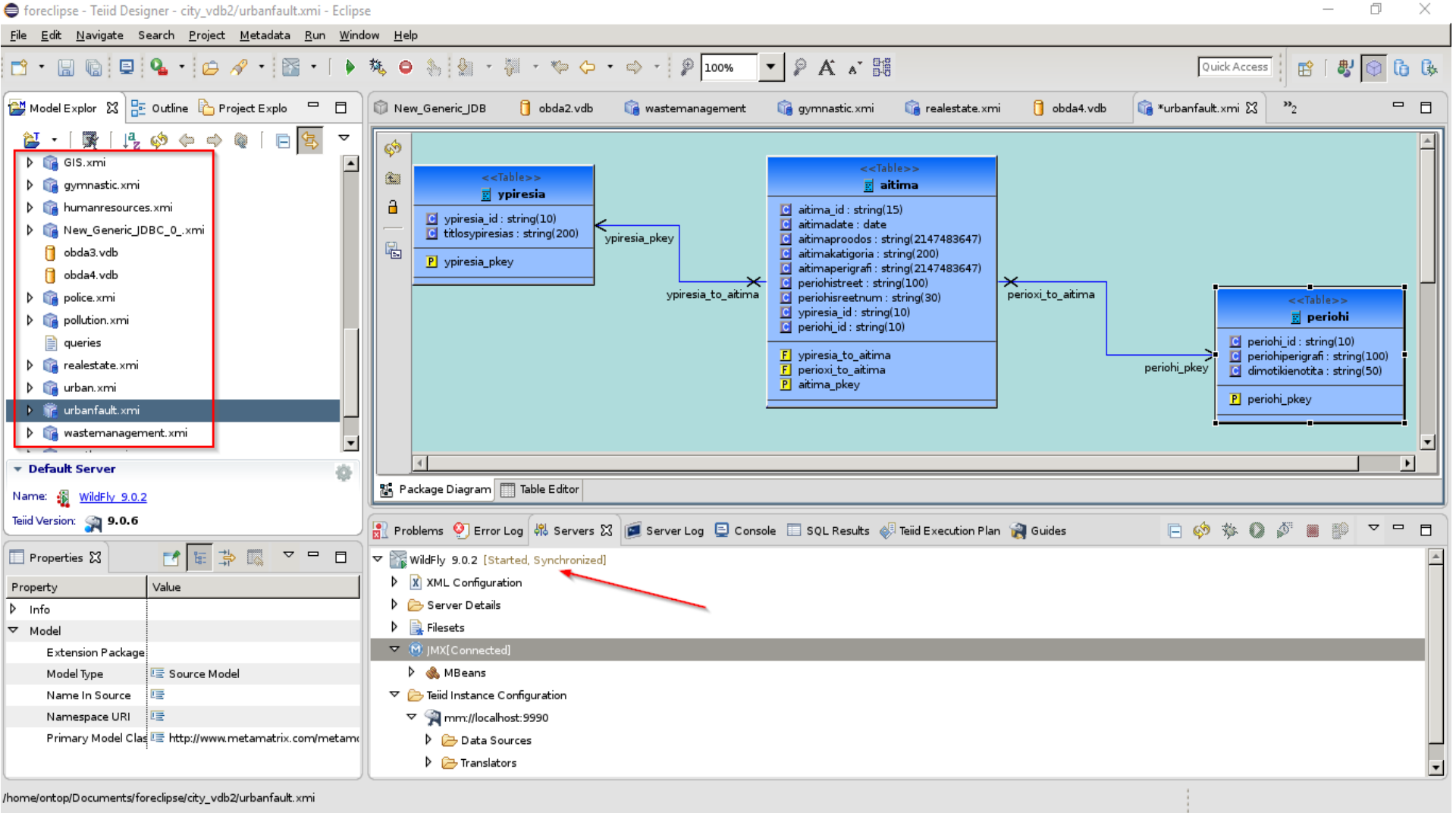
- JBoss server
- Eclipse Neon
- Teiid Designer

Virtual database creation
(points that need attention)

- **"Demanding" configuration of the JDBC connection between the JBoss server (Teiid VDB) and the postgreSQL server (Postgres DB)**
- **Differences in the datatypes between the two databases**

  It is important to record the mapping to identify any errors during the implementation

Virtual database environment

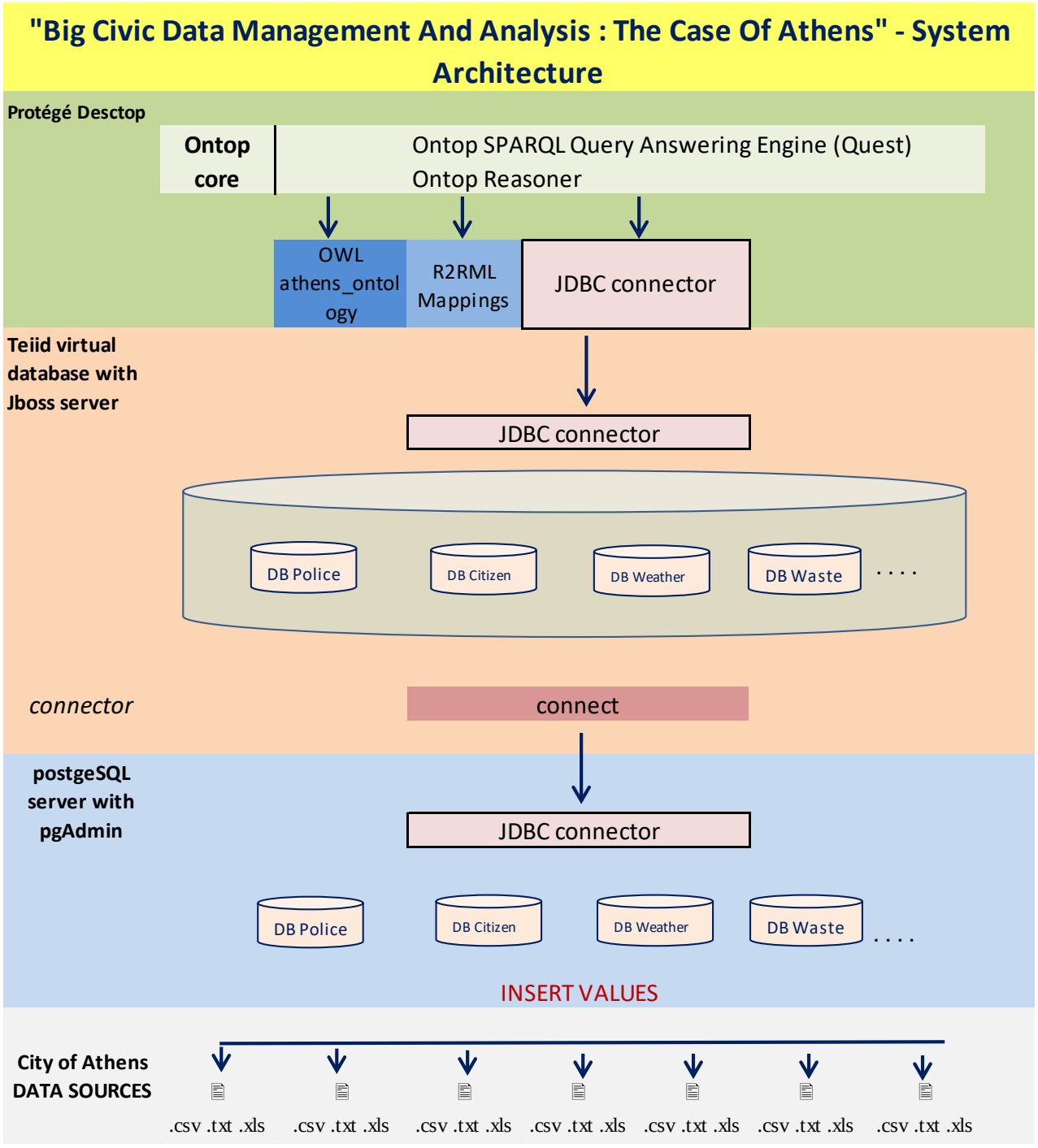


System completion (protégé software)

Installing **Protégé 5.1.**0. (ontology editor) and **onTop** plug -in, an OBDA framework, completes the overall architecture of the system.

Through this architecture, it is possible to highlight the Ontology-Based Data Access Approach.

System overview



Ontology–Based Data Access

Implementation of the Ontology–Based Data Access approach

It is required:

- The use (or creation) of a field ontology describing the operation of a major Greek city
- The creation of local databases to connect with ontology
- Creating mappings of ontology with underlying databases

Reuse (*creation*) of the ontology

INITIAL PLANNING

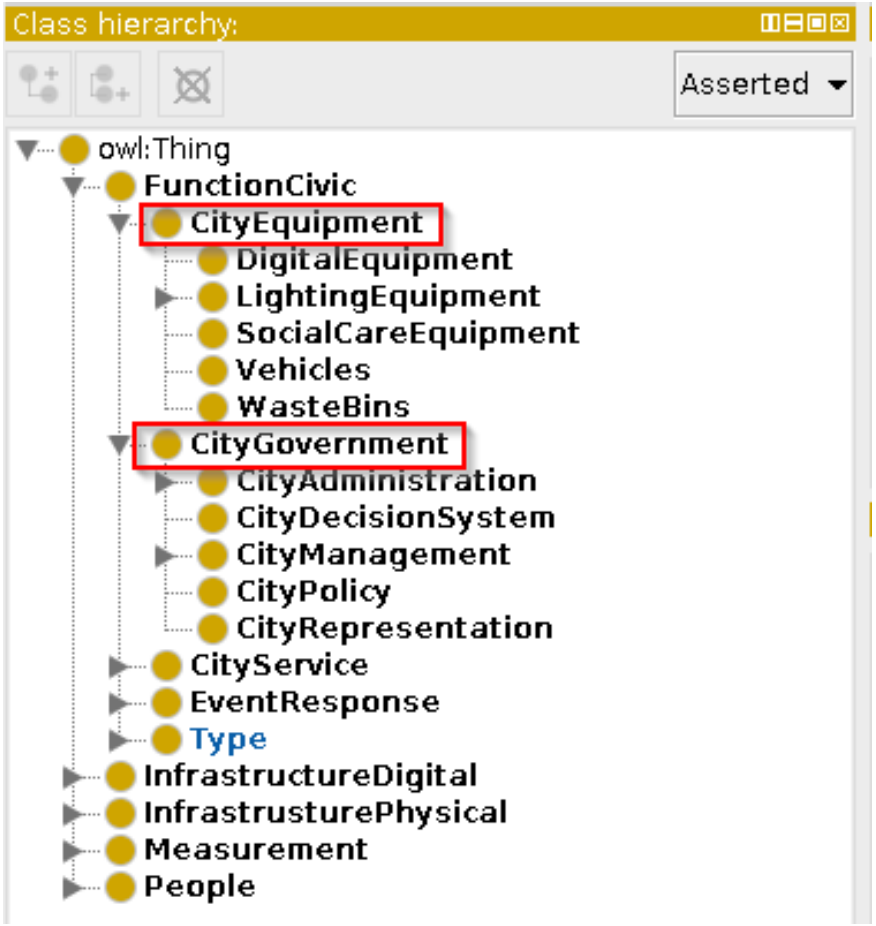
- Reuse and enrich existing ontologies
- Then connect to the databases created

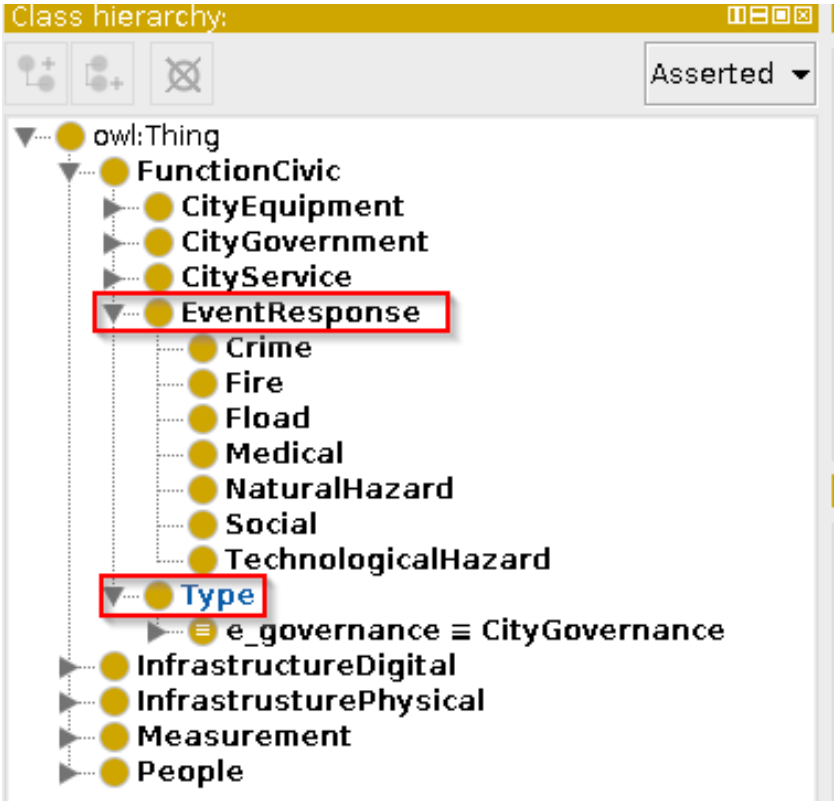
FINDINGS……DURING THE IMPLEMENTATION

- Lack of available (free) city ontologies
- Problems in examining the possibility of using existing ontologies

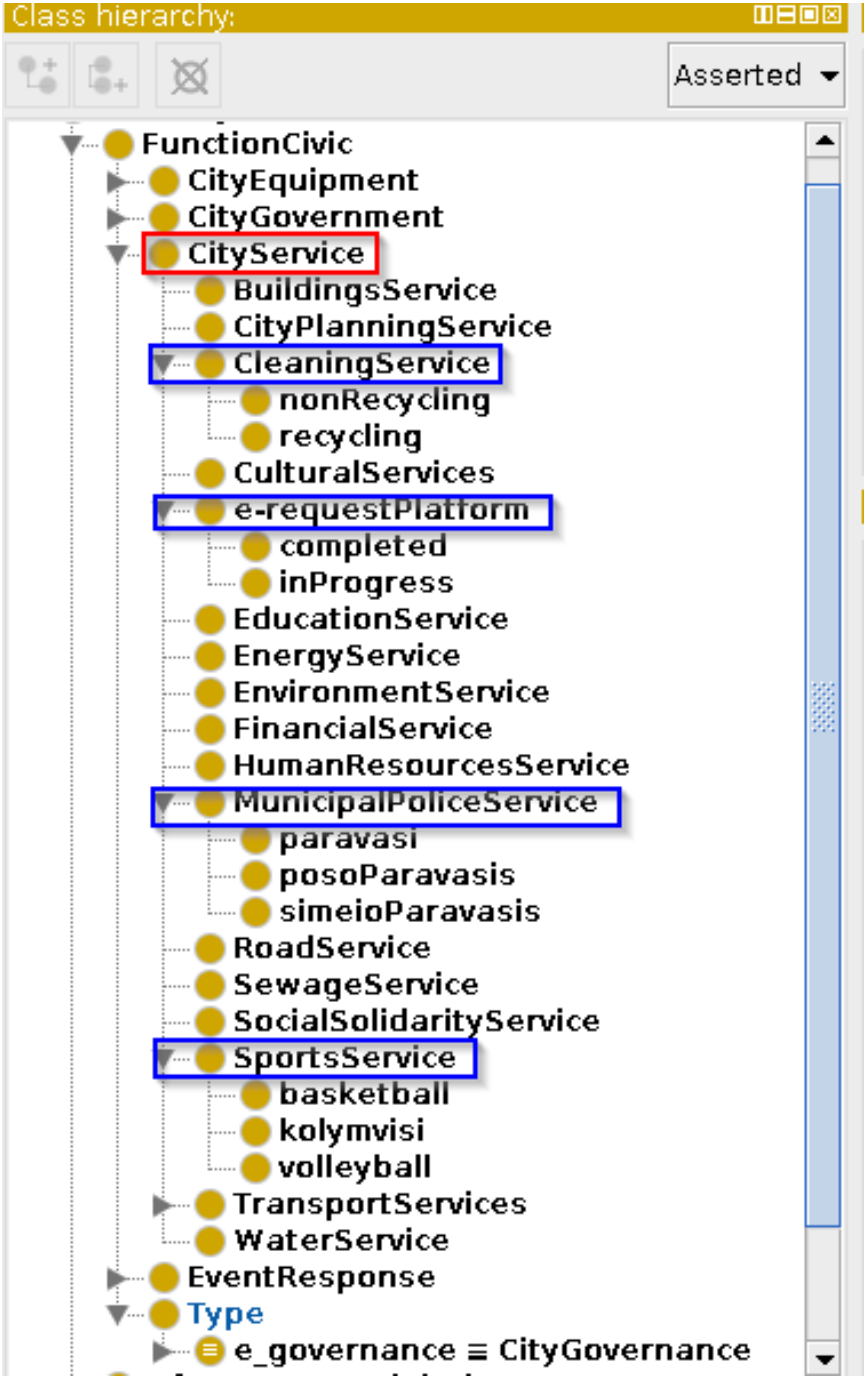
Ontology creation

(Super)Class FunctionCivic





Ontology creation
(Super) Class FunctionCivic

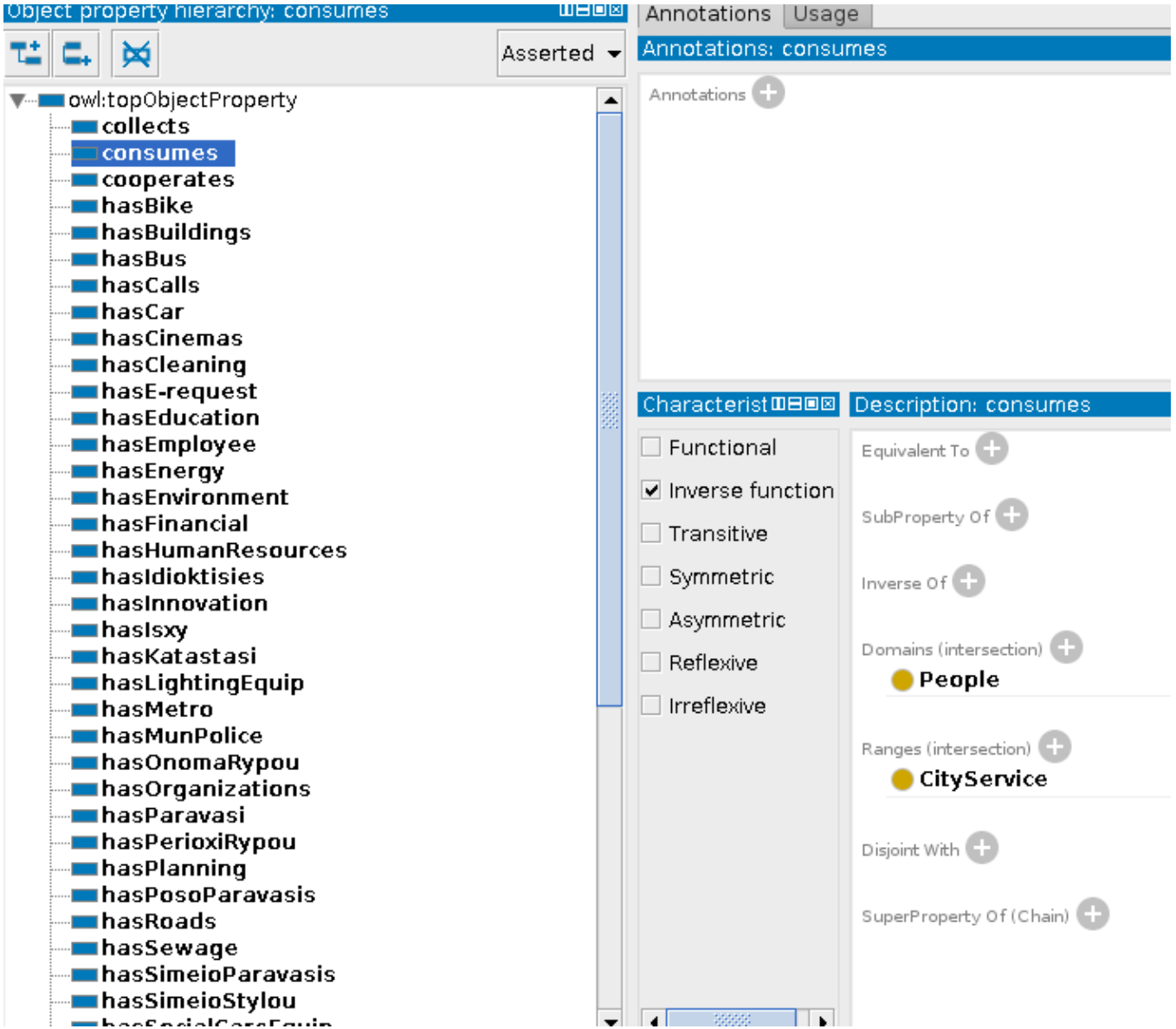


Ontology creation
(Classes, Object and Data Properties)

- Creation of classes and subclasses
- Creation of Object properties (*and subproperties*)
- Inverse properties and symmetric properties
- Creation of dataproperties *(and subproperties)*
- Set Domain and Range to Object and Data Properties

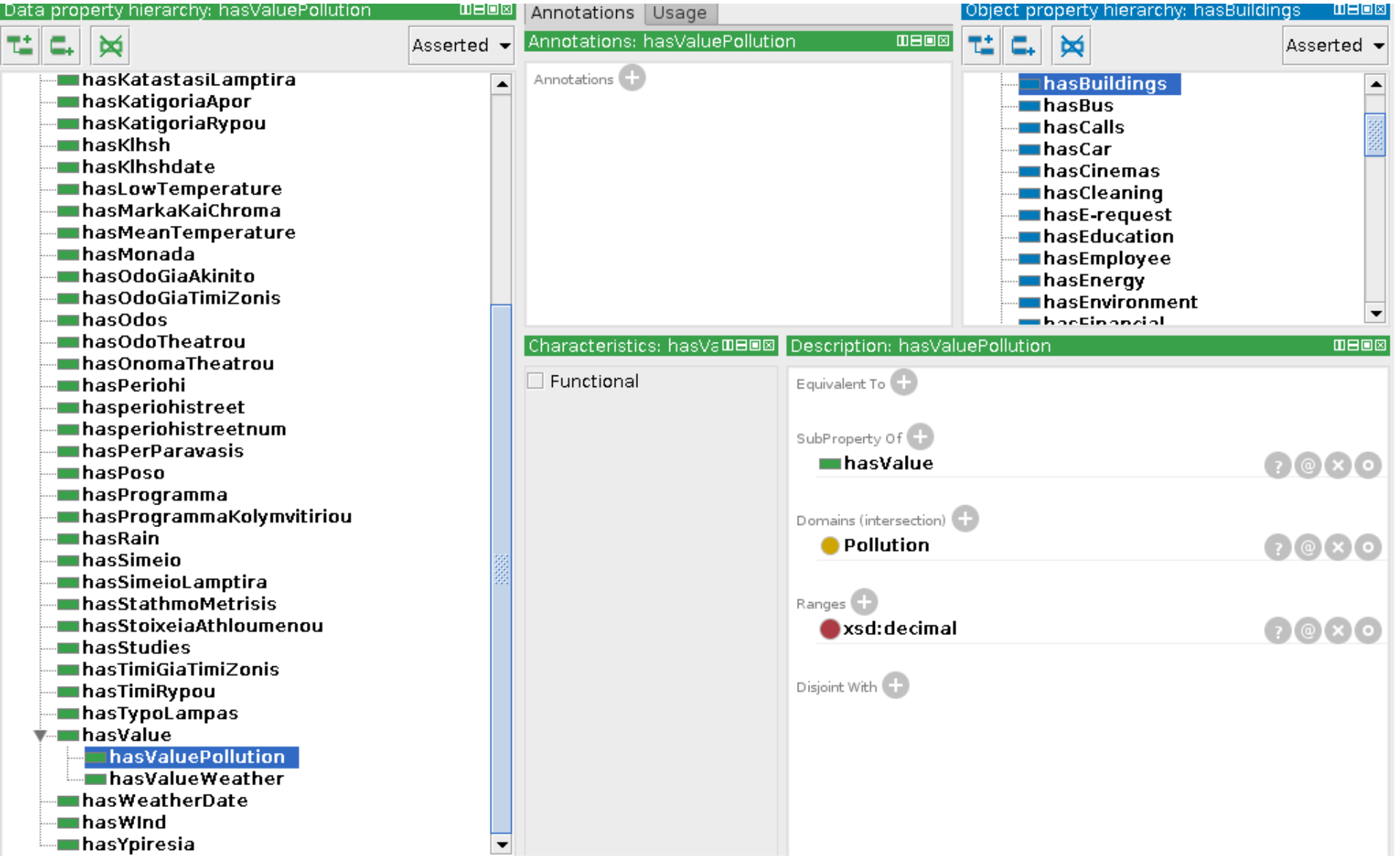
Ontology creation

(Object property -> consumes)



Ontology creation

(Data property -> hasValue)



Object property *consumes*
(Semantic triple)

People *consumes* CityService

(subject) (predicate) (object)

Human

People consume city services

Machine

http://www.semanticweb.org/aueb/cityontology/athens#People

http://www.semanticweb.org/aueb/cityontology/athens#Consumes

http://www.semanticweb.org/aueb/cityontology/athens#CityService

Mappings creation
(structure)

Mapping ID : urn:e-request date

Target (Triples template):

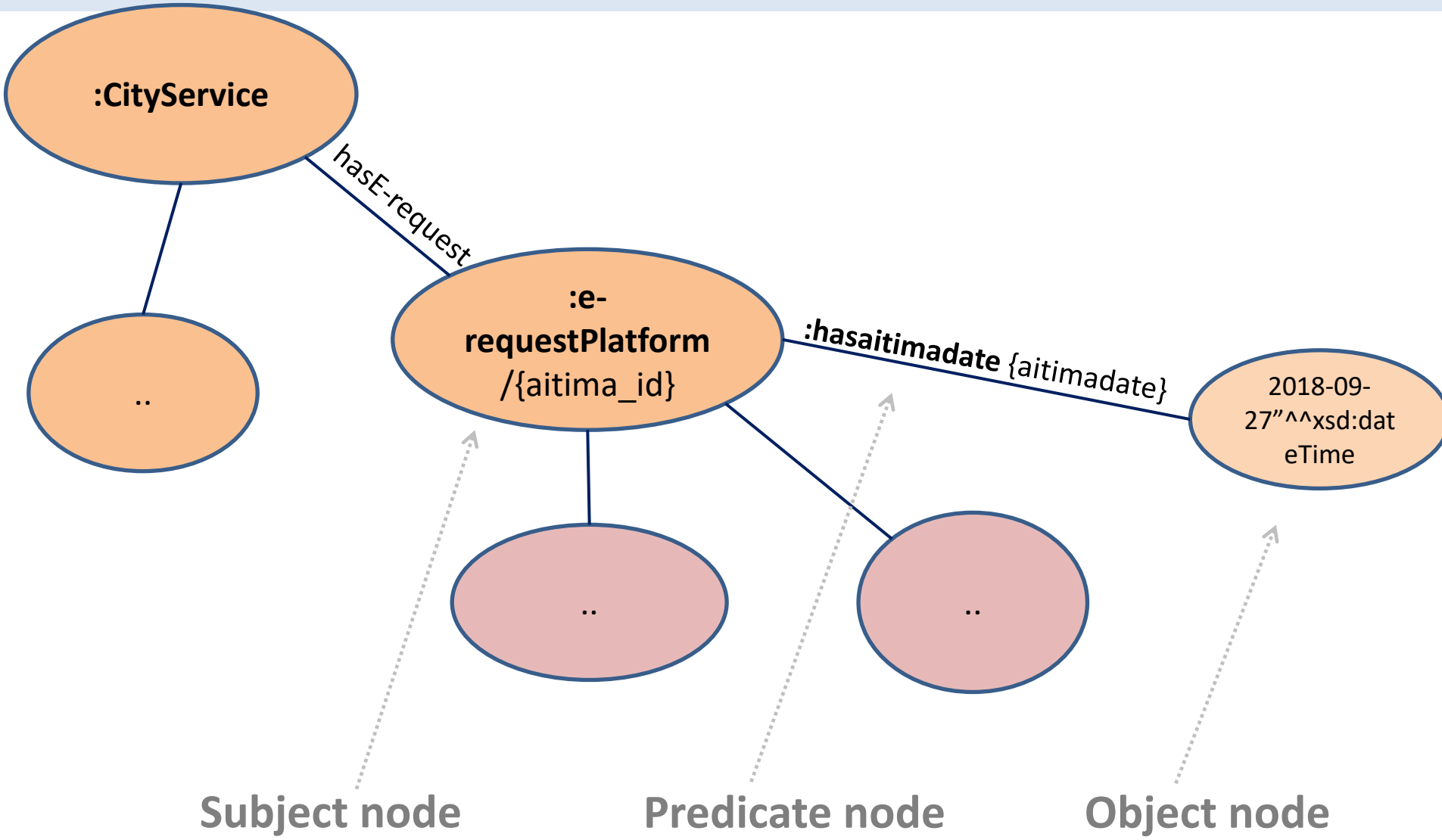
:e-requestPlatform/{aitima_id} a :e-requestPlatform ; :hasaitimadate {aitimadate}^^xsd:dateTime .

Source (SQL query)

```
SELECT aitima_id, aitimadate
FROM aitima
```

When designing each new mapping, the onTop's reasoner must be synchronized to control logical consistency with all existing mappings

Mappings creation
(mapping as an RDF graph)



Query execution
(Conditions)

- When executing queries, the connection to the databases must be active*(on-the-fly approach)*.

- Also, the onTop reasoner must be enabled to allow logical documentation of all concepts of ontology and query execution.

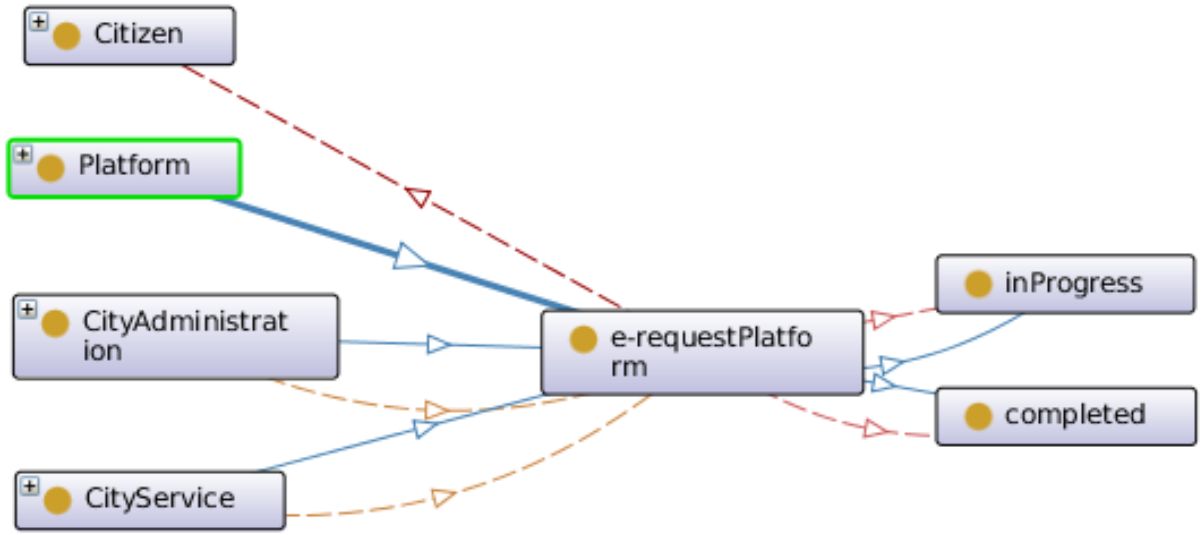
Query execution
(Main points)

- The language used to run queries is SPARQL (SPARQL Protocol and RDF Query Language)
- Queries are performed against the ontology rather than the databases
- Mappings are now disconnected from the query definition process
- The questions incorporate the knowledge of the field developed in the ontology

SPARQL query (example)

```
:e-requestPlatform/{aitima_id} a :e-requestPlatform ; :hasaitimaperigrafi
{aitimaperigrafi}^^xsd:string .
```

aitima_id	aitimaperigrafi
357453	ΕΠΕΙΓΟΝ.ΕΝΑ Φ/Σ ΕΝΑΕΡΙΟ ΕΙΝΑΙ ΣΒΗΣΤΟ.
238493	ΚΑΘΑΡΙΣΜΟΣ ΦΡΕΑΤΙΟΥ.
318239	ΕΝΤΟΝΗ ΔΥΣΟΣΜΙΑ ΑΠΟ ΤΟ ΦΡΕΑΤΙΟ ΕΠΙ ΤΟΥ ΟΔΟΣΤΡΩΜΑΤΟΣ ΝΑ ΓΙΝΕΙ ΕΛΕΓΧΟΣ.
237324	ΣΤΗΝ ΑΝΩ ΟΔΟ ΤΟ ΣΥΣΤΗΜΑ ΕΞΑΕΡΙΣΜΟΥ Κ.Υ.Ε. ΦΟΥΡΝΟΥ, ΜΕ ΔΙΑΚΡΙΤΙΚΟ ΤΙΤΛΟ "OK!BREAD" ΕΧΕΙ ΕΝΤΟΝΟ ΚΑ...
229491	Η ΔΗΜΟΤΗΣ ΖΗΤΑ ΝΑ ΟΛΟΚΛΗΡΩΘΕΙ Η ΕΡΓΑΣΙΑ ΑΠΟΣΥΡΣΗΣ ΤΟΥ ΠΕΡΙΠΤΕΡΟΥ.



SPARQL query

(damaged lighting bulbs and residents' complaints)

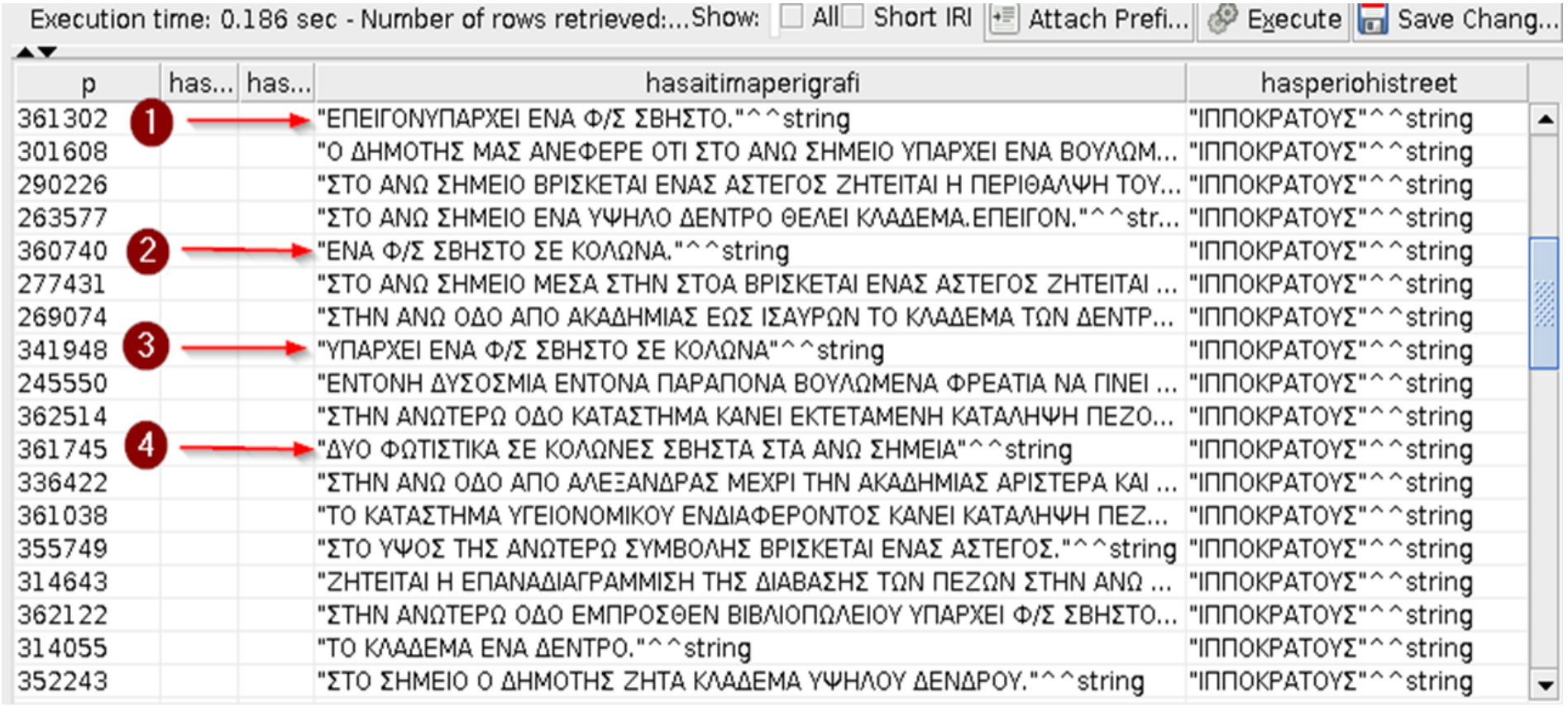
Scenario: A user working in the city's street lighting maintenance service is looking for residents' complaints about the roads where damaged lighting bulbs have been recorded

```
PREFIX : <http://www.semanticweb.org/aueb/cityontology/athens#>
PREFIX obda: <https://w3id.org/obda/vocabulary#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>


SELECT * WHERE {
{?p a :FunctionCivic; :hasSimeioLamptira ?hasSimeioLamptira .
  ?p a :FunctionCivic; :hasKatastasiLamptira ?hasKatastasiLamptira .
FILTER (?hasSimeioLamptira="ΙΠΠΟΚΡΑΤΟΥΣ"^^xsd:string && (?hasKatastasiLamptira="ΟΛΙΚΩΣ
ΚΑΤΕΣΤΡΑΜΜΕΝΟ"^^xsd:string))}
UNION
{?p a :FunctionCivic; :hasaitimaperigrafi ?hasaitimaperigrafi .
?p a :FunctionCivic; :hasperiohistreet ?hasperiohistreet .
FILTER (?hasperiohistreet="ΙΠΠΟΚΡΑΤΟΥΣ"^^xsd:string)}
}
```

SPARQL query

(damaged lighting bulbs and residents' complaints)



p	has...	has...	hasaitimaperigrafi	hasperiohistreet
361302			"ΕΠΕΙΓΟΝΥΠΑΡΧΕΙ ΕΝΑ Φ/Σ ΣΒΗΣΤΟ."^^string	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
301608			"Ο ΔΗΜΟΤΗΣ ΜΑΣ ΑΝΕΦΕΡΕ ΟΤΙ ΣΤΟ ΑΝΩ ΣΗΜΕΙΟ ΥΠΑΡΧΕΙ ΕΝΑ ΒΟΥΛΩΜ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
290226			"ΣΤΟ ΑΝΩ ΣΗΜΕΙΟ ΒΡΙΣΚΕΤΑΙ ΕΝΑΣ ΑΣΤΕΓΟΣ ΖΗΤΕΙΤΑΙ Η ΠΕΡΙΘΑΛΨΗ ΤΟΥ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
263577			"ΣΤΟ ΑΝΩ ΣΗΜΕΙΟ ΕΝΑ ΥΨΗΛΟ ΔΕΝΤΡΟ ΘΕΛΕΙ ΚΛΑΔΕΜΑ.ΕΠΕΙΓΟΝ."^^str...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
360740			"ΕΝΑ Φ/Σ ΣΒΗΣΤΟ ΣΕ ΚΟΛΩΝΑ."^^string	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
277431			"ΣΤΟ ΑΝΩ ΣΗΜΕΙΟ ΜΕΣΑ ΣΤΗΝ ΣΤΟΑ ΒΡΙΣΚΕΤΑΙ ΕΝΑΣ ΑΣΤΕΓΟΣ ΖΗΤΕΙΤΑΙ ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
269074			"ΣΤΗΝ ΑΝΩ ΟΔΟ ΑΠΟ ΑΚΑΔΗΜΙΑΣ ΕΩΣ ΙΣΑΥΡΩΝ ΤΟ ΚΛΑΔΕΜΑ ΤΩΝ ΔΕΝΤΡ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
341948			"ΥΠΑΡΧΕΙ ΕΝΑ Φ/Σ ΣΒΗΣΤΟ ΣΕ ΚΟΛΩΝΑ"^^string	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
245550			"ΕΝΤΟΝΗ ΔΥΣΟΣΜΙΑ ΕΝΤΟΝΑ ΠΑΡΑΠΟΝΑ ΒΟΥΛΩΜΕΝΑ ΦΡΕΑΤΙΑ ΝΑ ΓΙΝΕΙ ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
362514			"ΣΤΗΝ ΑΝΩΤΕΡΩ ΟΔΟ ΚΑΤΑΣΤΗΜΑ ΚΑΝΕΙ ΕΚΤΕΤΑΜΕΝΗ ΚΑΤΑΛΗΨΗ ΠΕΖΟ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
361745			"ΔΥΟ ΦΩΤΙΣΤΙΚΑ ΣΕ ΚΟΛΩΝΕΣ ΣΒΗΣΤΑ ΣΤΑ ΑΝΩ ΣΗΜΕΙΑ"^^string	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
336422			"ΣΤΗΝ ΑΝΩ ΟΔΟ ΑΠΟ ΑΛΕΞΑΝΔΡΑΣ ΜΕΧΡΙ ΤΗΝ ΑΚΑΔΗΜΙΑΣ ΑΡΙΣΤΕΡΑ ΚΑΙ ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
361038			"ΤΟ ΚΑΤΑΣΤΗΜΑ ΥΓΕΙΟΝΟΜΙΚΟΥ ΕΝΔΙΑΦΕΡΟΝΤΟΣ ΚΑΝΕΙ ΚΑΤΑΛΗΨΗ ΠΕΖ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
355749			"ΣΤΟ ΥΨΟΣ ΤΗΣ ΑΝΩΤΕΡΩ ΣΥΜΒΟΛΗΣ ΒΡΙΣΚΕΤΑΙ ΕΝΑΣ ΑΣΤΕΓΟΣ."^^string	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
314643			"ΖΗΤΕΙΤΑΙ Η ΕΠΑΝΑΔΙΑΓΡΑΜΜΙΣΗ ΤΗΣ ΔΙΑΒΑΣΗΣ ΤΩΝ ΠΕΖΩΝ ΣΤΗΝ ΑΝΩ ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
362122			"ΣΤΗΝ ΑΝΩΤΕΡΩ ΟΔΟ ΕΜΠΡΟΣΘΕΝ ΒΙΒΛΙΟΠΩΛΕΙΟΥ ΥΠΑΡΧΕΙ Φ/Σ ΣΒΗΣΤΟ...	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
314055			"ΤΟ ΚΛΑΔΕΜΑ ΕΝΑ ΔΕΝΤΡΟ."^^string	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string
352243			"ΣΤΟ ΣΗΜΕΙΟ Ο ΔΗΜΟΤΗΣ ΖΗΤΑ ΚΛΑΔΕΜΑ ΥΨΗΛΟΥ ΔΕΝΔΡΟΥ."^^string	"ΙΠΠΟΚΡΑΤΟΥΣ"^^string

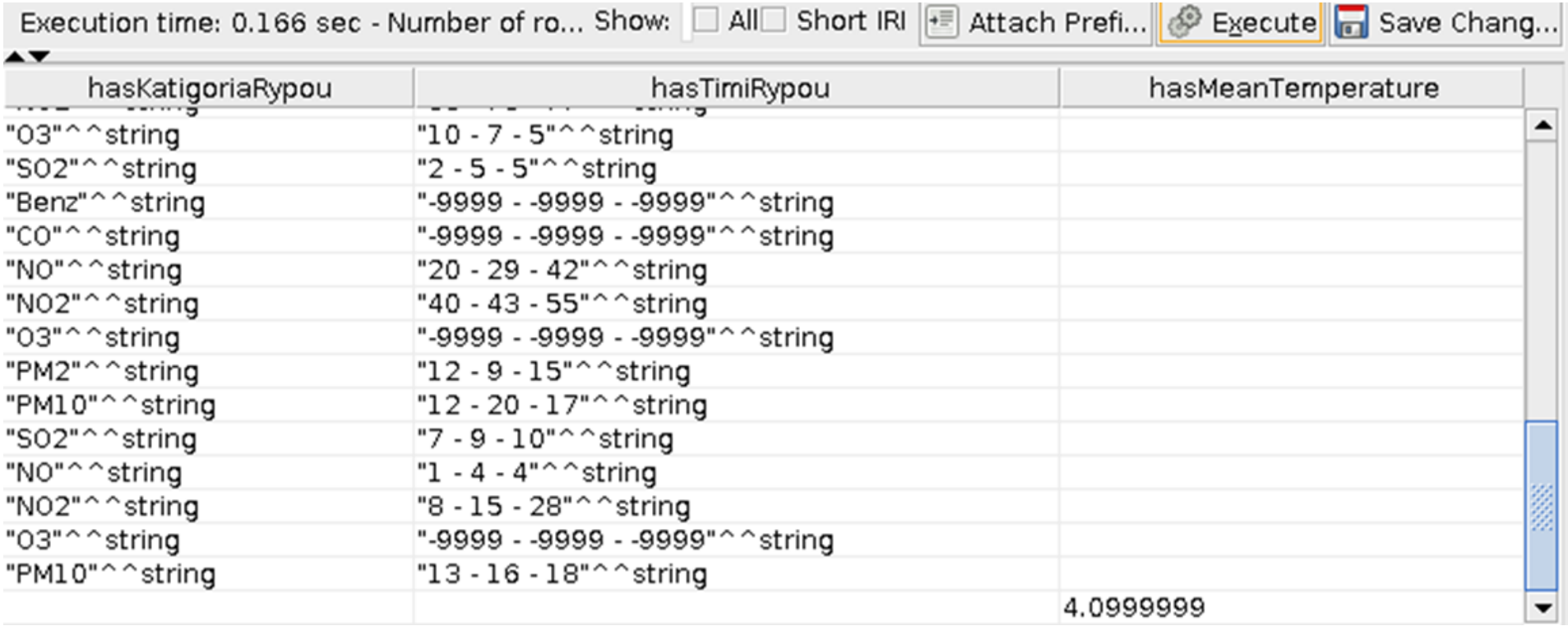
SPARQL query
(air pollution and temperature correlation)

Scenario: For temperature values <> d ° C in weather station A, find the values of the pollutants (to the nearest pollutant measurement sensor)

```
PREFIX : <http://www.semanticweb.org/aueb/cityontology/athens#>
PREFIX obda: <https://w3id.org/obda/vocabulary#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>


SELECT  ?hasMeanTemperature  ?hasTimiRypou  ?hasKatigoriaRypou WHERE {
   {?p a :Sensor; :hasMeanTemperature ?hasMeanTemperature .
 ?p a :Sensor; :hasWeatherDate "2016-12-31"^^xsd:date .}
UNION
{?p a :Sensor; :hasTimiRypou ?hasTimiRypou .
?p a :Sensor; :hasDateRypou "2016-12-31"^^xsd:date .
?p a :Sensor; :hasKatigoriaRypou ?hasKatigoriaRypou .
?p a :Sensor; :hasDateRypou "2016-12-31"^^xsd:date .}
}
```

SPARQL query
(air pollution and temperature correlation)



hasKatigoriaRypou	hasTimiRypou	hasMeanTemperature
"O3"^^string	"10 - 7 - 5"^^string	
"SO2"^^string	"2 - 5 - 5"^^string	
"Benz"^^string	"-9999 - -9999 - -9999"^^string	
"CO"^^string	"-9999 - -9999 - -9999"^^string	
"NO"^^string	"20 - 29 - 42"^^string	
"NO2"^^string	"40 - 43 - 55"^^string	
"O3"^^string	"-9999 - -9999 - -9999"^^string	
"PM2"^^string	"12 - 9 - 15"^^string	
"PM10"^^string	"12 - 20 - 17"^^string	
"SO2"^^string	"7 - 9 - 10"^^string	
"NO"^^string	"1 - 4 - 4"^^string	
"NO2"^^string	"8 - 15 - 28"^^string	
"O3"^^string	"-9999 - -9999 - -9999"^^string	
"PM10"^^string	"13 - 16 - 18"^^string	
		4.0999999

SPARQL queries
(more queries)

- Search for complaints from residents of the city on routes (or isolated routes) of the trash
  - **Optimization of routes and bin placement**
- Searching for the number, specialties and level of study in units related to most requests / complaints from residents
  - **Human resource management and training policy**
- Correlation of illegal parking violations in the city center with corresponding complaints from residents
  - **Degree of delinquency and timely intervention by municipal police**