A Hypercat-enabled Semantic Internet of Things Data Hub

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Outline

- Motivation
- BT Hypercat Data Hub
- BT Hypercat Ontology
- Data Translation
- BT SPARQL Endpoint
- Federated Querying
- Use Cases
- Future Directions

Motivation (1/4)

- **Smart city** is based on the use of technology in order to improve:
  - efficiency
  - effectiveness
  - city services
  - quality of the inhabitants' lives
- Successful smart city solutions require the collection and maintenance of relevant sensor data (IoT data)

Motivation (2/4)

- Eight industry-led projects were funded by Innovate UK to deliver IoT 'clusters'
- The **BT Hypercat Data Hub** was part of the Internet of Things Ecosystem Demonstrator programme
- Hypercat was developed, which is a standard for representing and exposing Internet of Things data hub catalogues

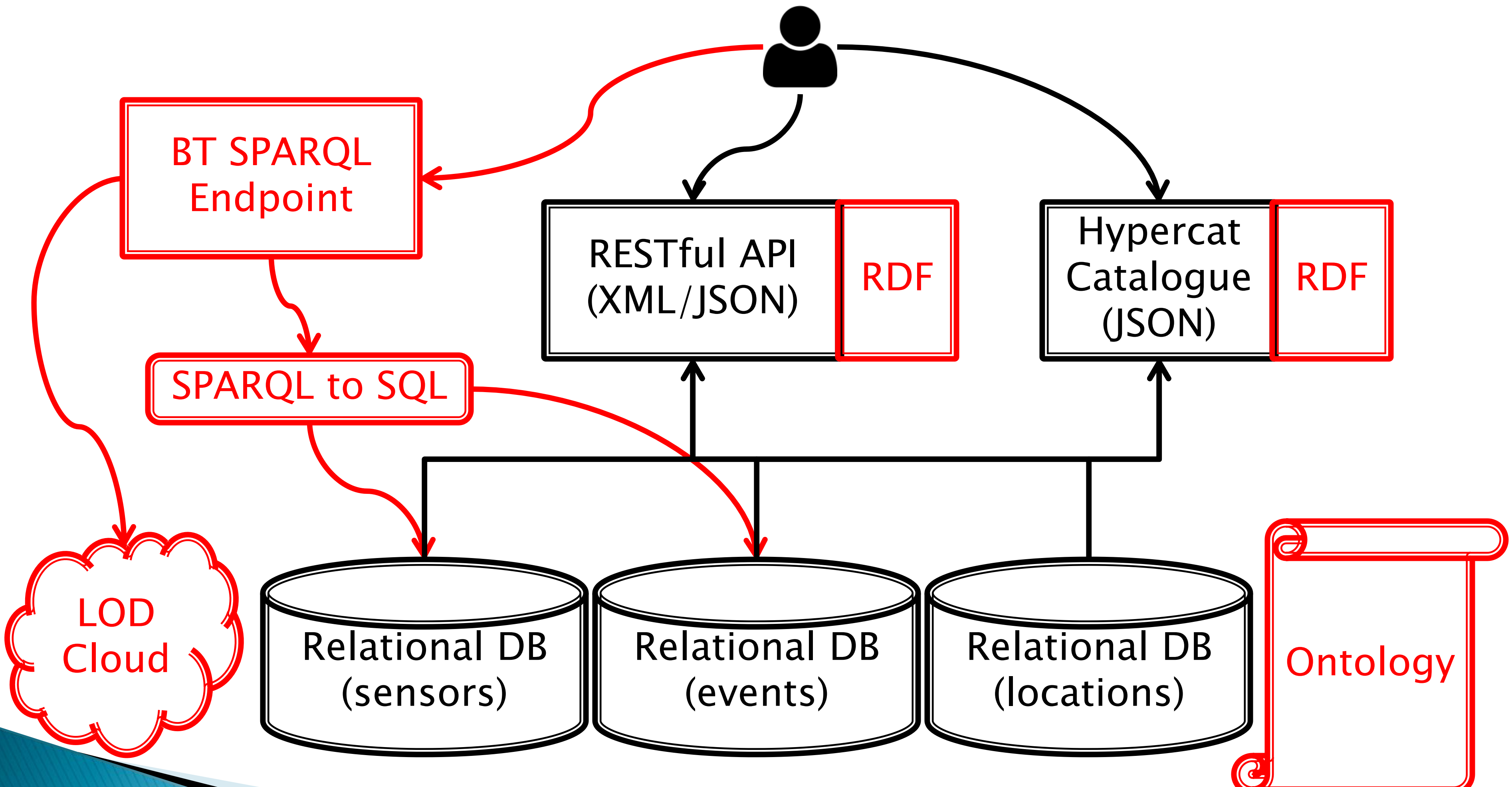
Motivation (3/4)

- IoT / smart city projects include:
  - Barcelona (http://ibarcelona.bcn.cat/en/smart-cities)
  - MK:Smart (http://www.mksmart.org), based on the BT Data Hub that is Hypercat-enabled but not semantically enriched

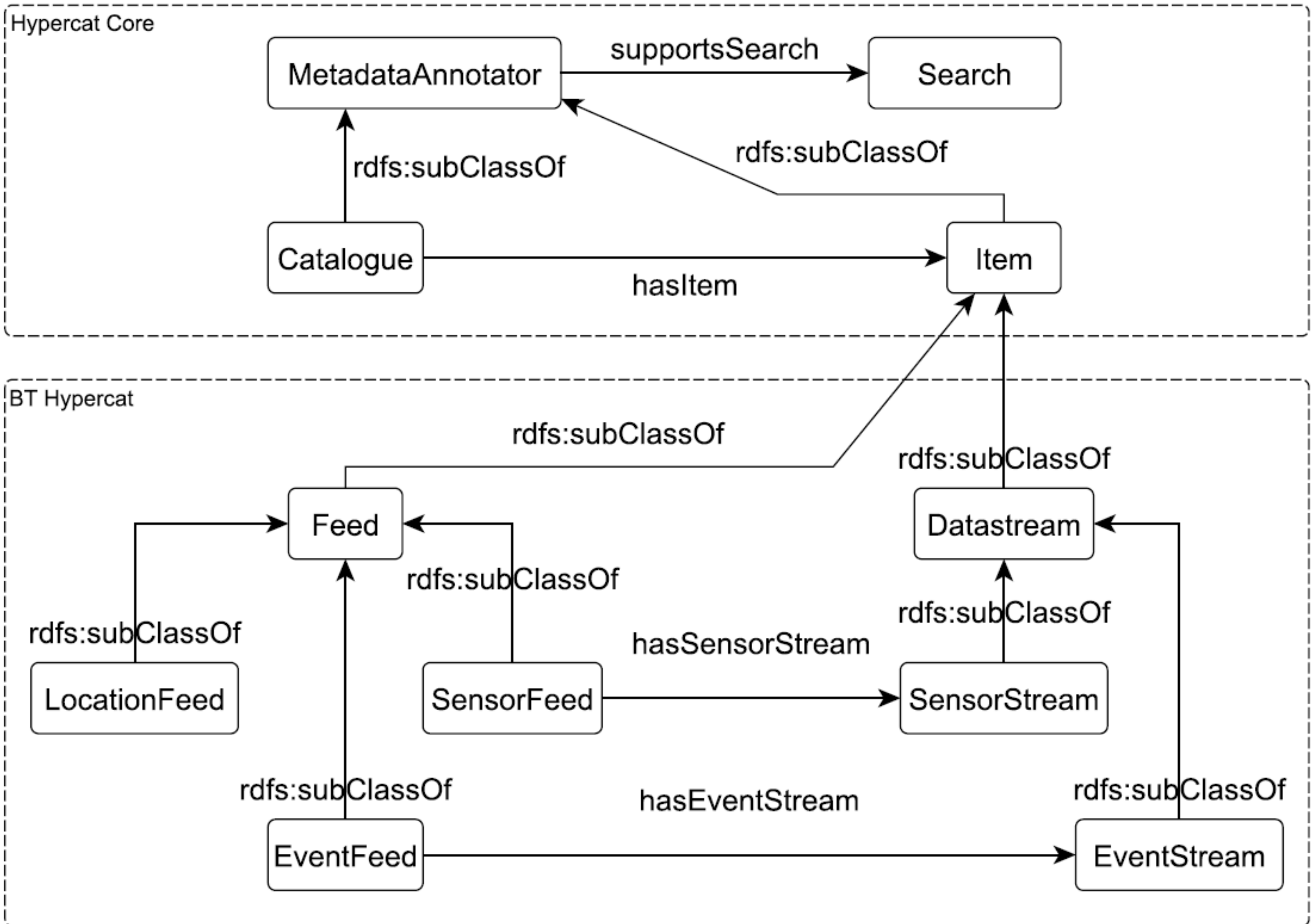
Motivation (4/4)

- Smart city solutions need to combine data from various sources and be interoperable
  - Adding semantics to data is the best way of ensuring interoperability and improving data quality through enrichment
- The aim of this work was to add semantics to the BT Data Hub

BT Hypercat Data Hub



BT Hypercat Ontology (1/4)



BT Hypercat Ontology (2/4)

- Hypercat Core URI:
  - http://portal.bt-hypercat.com/ontologies/hypercat
- BT Hypercat URI:
  - http://portal.bt-hypercat.com/ontologies/bt-hypercat

BT Hypercat Ontology (3/4)

- **Feed**: a source of sensor readings, events or locations
- Subclasses of **Feed**:
  - **SensorFeed**: a source of sensor readings
  - **EventFeed**: a source of events
  - **LocationFeed**: a source of locations

BT Hypercat Ontology (4/4)

- A **Feed** contains classes of type of **Datastream** or **Location**
- **Datastream**: a stream of sensor readings or events
- Subclasses of **Datastream**:
  - **SensorStream**: a stream of sensor readings
  - **EventStream**: a stream of events

Data Translation – RDF Adapter (1/2)

- RDF triple is provided within a single line, in N-Triples format, namely:
  - <subject> <predicate> <object> .
- The URI of a **SensorFeed** is generated as:
  - <http://api.bt-hypercat.com/sensors/feeds/feedID>

Prefix

Data type

Feed + ID

Data Translation – RDF Adapter (2/2)

- An RDF triple providing the type of a **SensorFeed**:

<http://api.bt-hypercat.com/sensors/feeds/feedID>

<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>

<http://portal.bt-hypercat.com/ontologies/bt-hypercat#SensorFeed>

Data Translation – SPARQL to SQL (1/2)

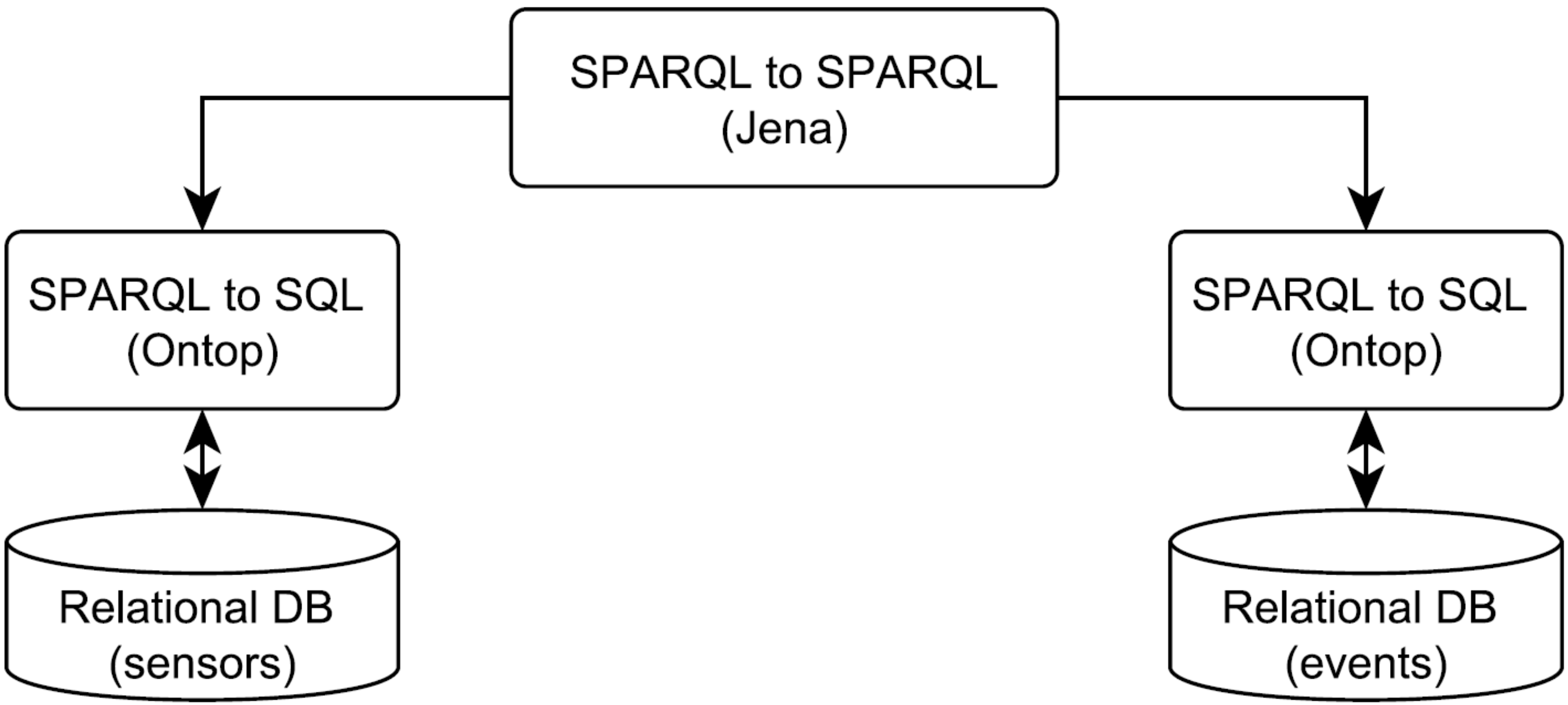
- Dynamic translation of SPARQL queries into SQL, using Ontop
- Implicit information is extracted from the ontology through reasoning (RDFS, OWL 2 QL)
- Semantically richer information is extracted compared to the knowledge that is stored in the relational database
- URI prefixes:
  - bt-sensors: http://api.bt-hypercat.com/sensors/
  - bt-hypercat: http://portal.bt-hypercat.com/ontologies/bt-hypercat#

Data Translation – SPARQL to SQL (2/2)

- Mapping ID: a unique id for a given mapping
- Target (Triple Template): RDF triple pattern to be generated (SQL variables are given in braces, such as {feed.id})
- Source (SQL Query): SQL query to be submitted to the relational database

Mapping ID	mapping:SensorFeed
Target (Triple Template)	bt-sensors:feeds/{feed.id} a bt-hypercat:SensorFeed
Source (SQL Query)	SELECT feed.id FROM feed

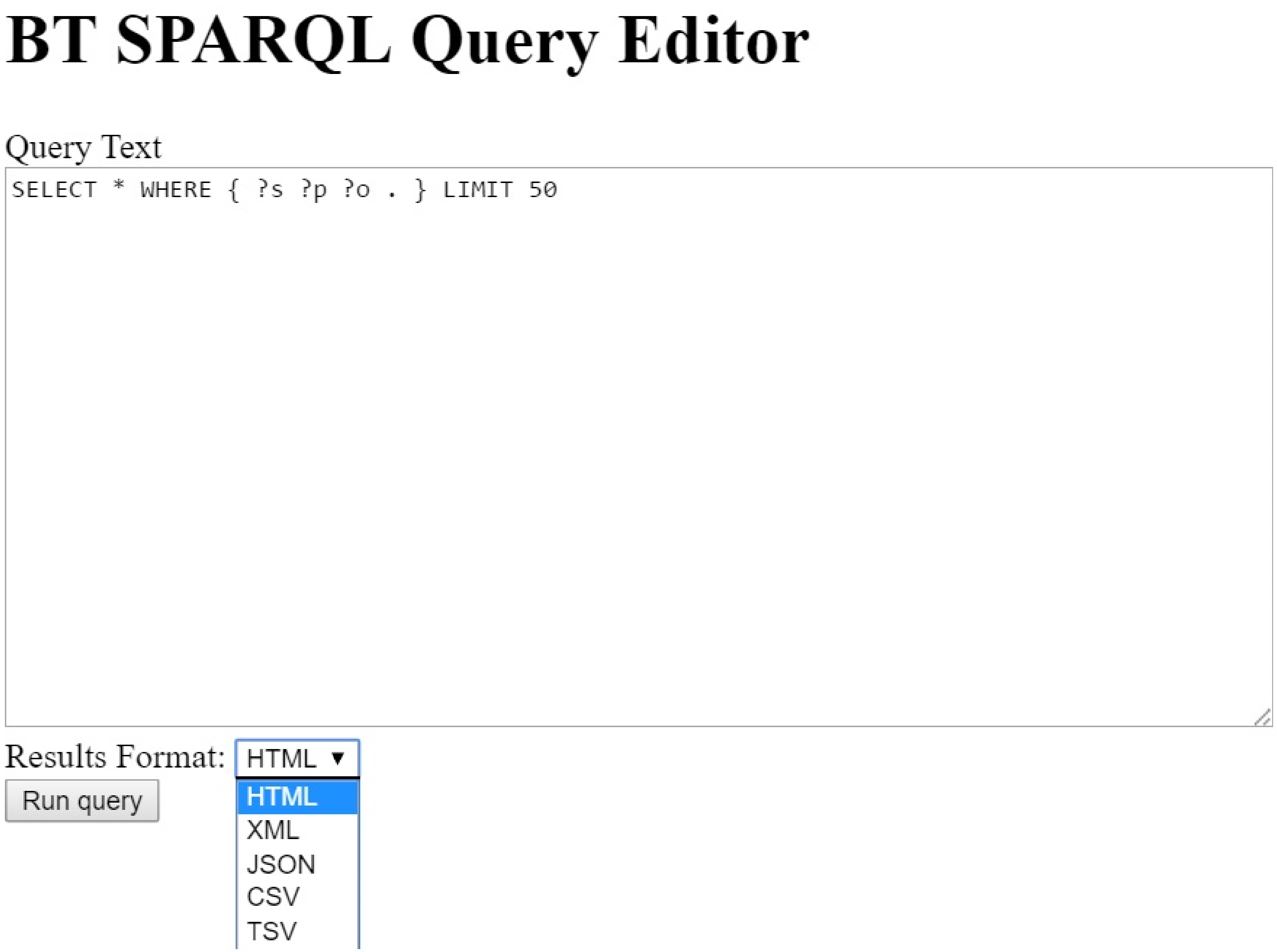
BT SPARQL Endpoint (1/5)



BT SPARQL Endpoint (2/5)

- **SPARQL to SQL**: supports the translation of SPARQL queries to relational databases, using Ontop
- **SPARQL to SPARQL**: queries internally all available **SPARQL to SQL** endpoints, using Apache Jena
- End users submit queries to the **SPARQL to SPARQL** endpoint

BT SPARQL Endpoint (3/5)



BT SPARQL Endpoint (4/5)

- BT SPARQL Query Editor: User Interface that allows graphic submission of queries
- Results are returned in five formats: HTML, XML, JSON, CSV and TSV

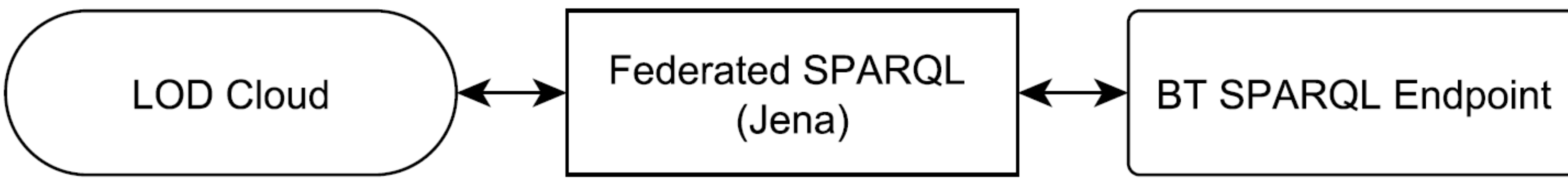
BT SPARQL Endpoint (5/5)

- The following query retrieves classes of type **Datastream** (and its subclasses, namely SensorStream and EventStream):

```
PREFIX hypercat: <http://portal.bt-hypercat.com/ontologies/bt-hypercat#>
SELECT DISTINCT ?s
WHERE{ ?s a hypercat:Datastream . }
```

Federated Querying (1/2)

- **Federated SPARQL** supports federated queries that combine the BT SPARQL Endpoint with the LOD cloud, using Apache Jena



Federated Querying (2/2)

- External SPARQL endpoints that are part of the LOD and could be combined with the BT SPARQL Endpoint:
  - DBPedia
  - FactForge
  - OpenUpLabs
  - European Environment Agency

Use Cases – The SimplifAI Project (1/2)

- Aimed at urban traffic management and control
- Targeting a higher level of data integration, while capturing and exploiting real-time and historical urban data sources
- Traffic management utilised the semantically enriched data
- Strategies in real-time were enabled to solve challenges caused by exceptional or unexpected conditions

Use Cases – The SimplifAI Project (2/2)

- Raw data was taken from a large number of transport and environment sources, and integrated into the BT Hypercat Data Hub
- Automated Planning was able to alleviate traffic congestion caused by exceptional circumstances
- Simulations showed that on average, the area is de-congested 20% faster, and tail-pipe emissions are reduced by 2.5%.

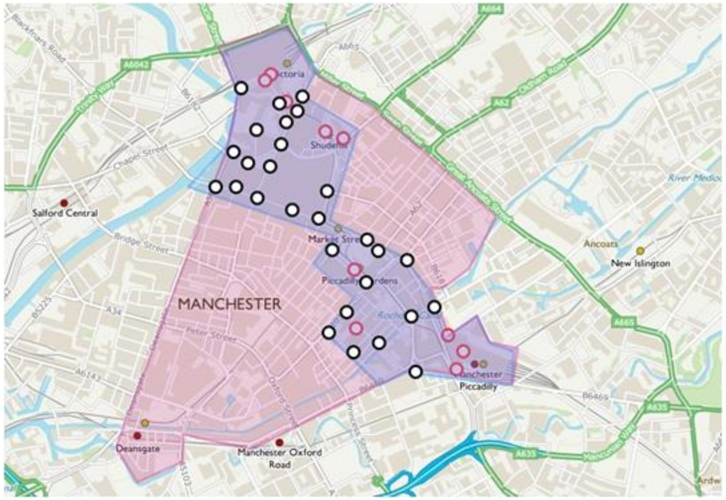
Use Cases – City Concierge (1/3)

- CityVerve is a Manchester, UK based IoT Demonstrator project
- City Concierge is one of CityVerve's use cases
- City Concierge aims to increase uptake of walking and cycling as a preferred travel mode in Greater Manchester
- City Concierge aims to develop a city user interface for the city region, integrating transportation and visitor services

Use Cases – City Concierge (2/3)

- The scope of the use case includes:
  - improvements in the way people navigate around the city
  - a digital solution in conjunction with physical wayfinding assets
- The BT Hypercat Data Hub provides the required infrastructure and functionality in order to enable the City Concierge

Use Cases – City Concierge (3/3)



Future Work

- Further semantic enrichment of the implemented system
- Support for GeoSPARQL queries
- Spatiotemporal reasoning over stored data

Thank You!