Intelligent Urban Traffic Management via Semantic Interoperability Across Multiple Heterogeneous Mobility Data

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Abstract
Integrated exploitation of data sources in the mobility domain is key to providing added-value services to passengers, transport companies and authorities

Effective usage is hindered by interoperability issues

Introduction
Interoperability is key for enabling collabs between travel and transport industry players
The tangent project – maybe look for more info on this to be crazy

This paper tackles how semantic tech and knowledge graphs can tackle interoperability

Cities
- Athens
- Lisbon
- Greater Manchester
- Rennes

Several Issues to be addressed
- Datasets in different formats
- Using different data models
- Data services relying on different specs and tech
- Metadata describing data sources according to different profiles

Challenges and Related Field

Stakeholders need to communicate and exchange information effectively without losing meaning.
Stakeholder adopt different legacy systems

We will Investigate
- Existing products and services adopted by the case studies involved in Tangent
- The current landscape is characterized by
  - Open data portals managed at different levels (regional/national/EU)
    - These datasets could be not well documented
      - Not in interoperable format (custom csv)
      - Not updated
  - Solutions from different 3rd part vendors
    - Usually use custom data formats and don't have easy access

Break this down into five major challenges
- Locate
  - What data is available and where??
- Access
  - How to obtain the needed data
- Harmonize
  - How to convert the data to behave with the required model
- Integrate
  - How to ensure different data sources can be merged
- Extract
  - How to consume harmonized and integrated data

Locate and Access
Findability and discoverability of data
Implement data catalogues/portals to describe data sources through a set of metadata.
Second challenge is data accessibility
Data catalogues adopt different strategies for data access mainly associated with the archetectural choices for hosting and storage
Challenge – enable uniform access to heterogenous datasources for end users

Who's addressing this problem??
European commission through National Access Points (NAP) for mobility data.

- Each member of state would operate a NAP to share mobility data
- Although, even in the case of NAP's each member state adopted different approaches for their implementation
- For this reason the NAPCORE project is currently working on coordinating and harmonizing a platform like this around Europe

The adoption of structured meta data descriptors according to well known vocab (DCAT) is fundemental for facilitating searches within multiple data catelogues
This can be helped by proper data governance

https://transport.ec.europa.eu/transport-themes/smart-mobility/road/its-directive-and-action-plan/national-access-points_en

Harmonize Integrate and Extract
Related to the processing of (meta)data to enable their exploitation according to common semantics
Flexible solution is required to address heterogenous requirements in terms of:

- Schama and data transformation
  - Information manipulation to obtain sytactic (structural) and semantic interoperability of meta(data)
- Integration with existing data
  - Components generating or storing the data and/or data sinks (components consuming or archiving data)

Each stakeholder is responsible for defining mappings from their own dataset representations to the reference model(lifiting) and vice versa (lowering)

Two additional components are identified to support the solution: **Reference Conceptual Model** (defining common semantics and the composition and configuration of **Semantic Harmonization and Fusion Pipeline**

TANGENT Solution for Dynamic and Intelligent Multimodal Traffic Management

Outline each macro component in the overall system

Data Catalogue
Catalogue of digital assets available online and accessible by users
Different digital assets can be characterized by specifying a metadata descriptor according to a common metadata profile.
Can also harvest from existing portals (NAP's)

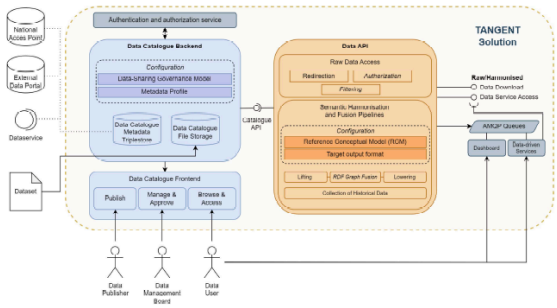

Fig. 1. Overview of the proposed solution for data interoperability

Reference Conceptual Model (RCM)

Supports the representation of heterogenous information from different data sources through a common ontological model to enable shared semantic and interporability.

Based on existing data standards to adopt correct domain terminology and covers all the representation of entities and properties required to implement meaningful data exchanges.

Not possible to recommend and well adopted ontology – there are many but they only cover specific requirements.

That means to start we must analyze existing data standards
Then following the best practice of reusing existing models -> add relevent ontologies to the RCM

Table 1 defines the 10 modules defined for the RCM

Table 1. Overview of the TANGENT Reference Conceptual Model

Module	Base Standard	Data Requirements	Reused ontologies

Road Transport Network	Datex II	Road Transport Network (roads, limited access zones, etc.)	GeoSPARQL, Basic Geo, Datex II JSON-LD (location, common)
Road Equipment	Datex II	Road Equipment Position	Datex II JSON-LD (location), DC Terms, Schema.org
Road Traffic Data	Datex II	Road Traffic Measurements (traffic occupancy, speed, flow) Floating Vehicle Data (GPS, mobile, etc.)	Datex II JSON-LD (traffic)
Road Travel Times	Datex II	Road Travel Times (external services, statistics, etc.)	Datex II JSON-LD (location, traffic)
Events	Datex II	Road Transport Network Events (planned) / Incidents (unplanned) Influencing Planned Events (sports, entertainment, etc.) Weather Events	Datex II JSON-LD (situation, location, common)
Weather Data	Datex II	Forecasted Weather Data Weather Data (measurements, e.g., temperature, humidity, etc.)	Datex II JSON-LD (location, traffic, common)
Stop Points	NeTEx	Public Transport Network	Transmodel ontology (commons, journeys), Basic Geo
Schedules	NeTEx	Public Transport Schedules and Lines	Transmodel ontology (commons, journeys, organisations)
Situation Exchange	SIRI	Public Transport Network Events (planned) / Incidents (unplanned)	Basic Geo
Vehicle Monitoring	SIRI	Floating PT Vehicle Data Public Transport Delays	Basic Geo

3.30 Semantic Harmonization and Fusion Pipeline

(a) the analysis of raw data sources stored in the Data Catalogue

(b) definition of the information required by the other components that are integrated into the solution and the related target output format

Slide 1

Explain what the paper plans to tackle (set up common semnatic layer and pipeline to fuse heterogenous mobility data to coordinate traffic across different modes (buses,carsetc.)

Slide 2 - Stakeholder impact

List the stakeholders involved and how this will improve operations for them
Relate back to the 5 challenges outlined in the paper
Locate – locate data on accident response (who can help with that? Who doesn't have this data and can now be combined with that stakeholders data?)

Standards and Resuable Ontologies

Mention DCAT and how structured metadata catalogues help search across portals
Explain how NAP will help
Analyse existing standards and best fit models (RCM's)

Architecture for getting the job done

What each block does what are the in/outs between blocks
Data catalogue
RCM
Semantic harmonizing and fusion

Case study analysis and before/after if possible

Risks and Short comings

Wrap up