

Optimizing Multi-Modal Transportation in Smart Cities: A Graph-Oriented Database Approach

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Project facts



DELPHI

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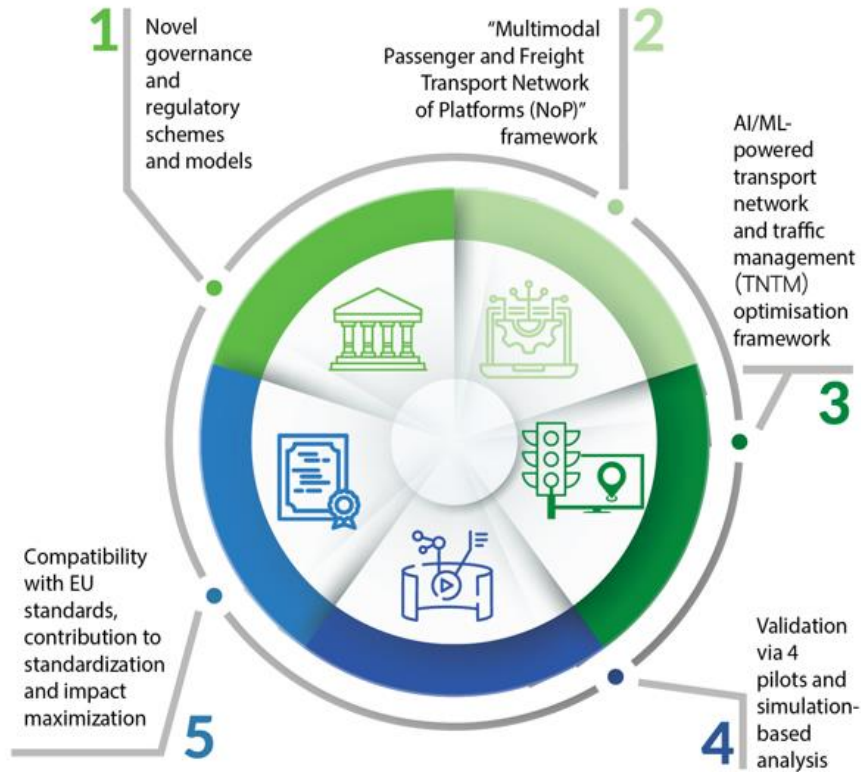
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Consortium



Objectives

Towards the overall project's concept and mission, the following five interdisciplinary implementation objectives have been defined:



USE CASE #1

Multimodal transport for a Sustainable LMD supported by blockchain for sharing economy in the e-commerce Channel in Madrid (Spain)



USE CASE #2

Integrated freight and passengers' models and data sharing framework in urban environment in the Attica region (Greece)



USE CASE #3

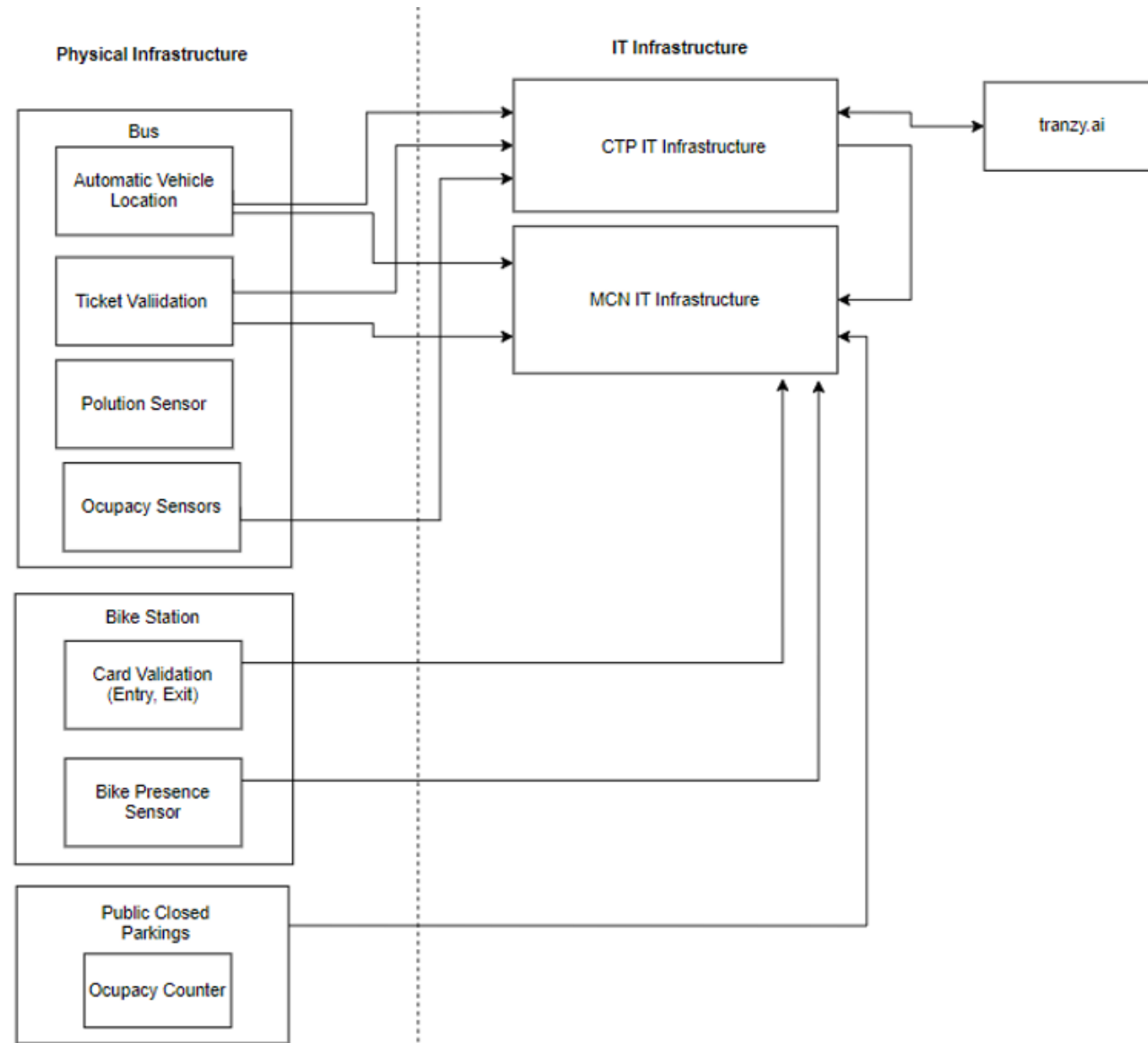
Integrated freight and passengers' models and data sharing framework in suburban/rural environment in the island of Mykonos (Greece)



USE CASE #4

Integrated passengers' models and data sharing governance framework in the Cluj-Napoca Metropolitan Area (Romania)

Cluj-Napoca Use Case



Objectives

- ▶ Model an interconnected urban transportation network using graph database
- ▶ Practical implementation based on Cluj-Napoca use-case
- ▶ Propose a data model to store several type of transportation nodes and link
- ▶ Explore different queries to demonstrate practical usability and functionality of this data model

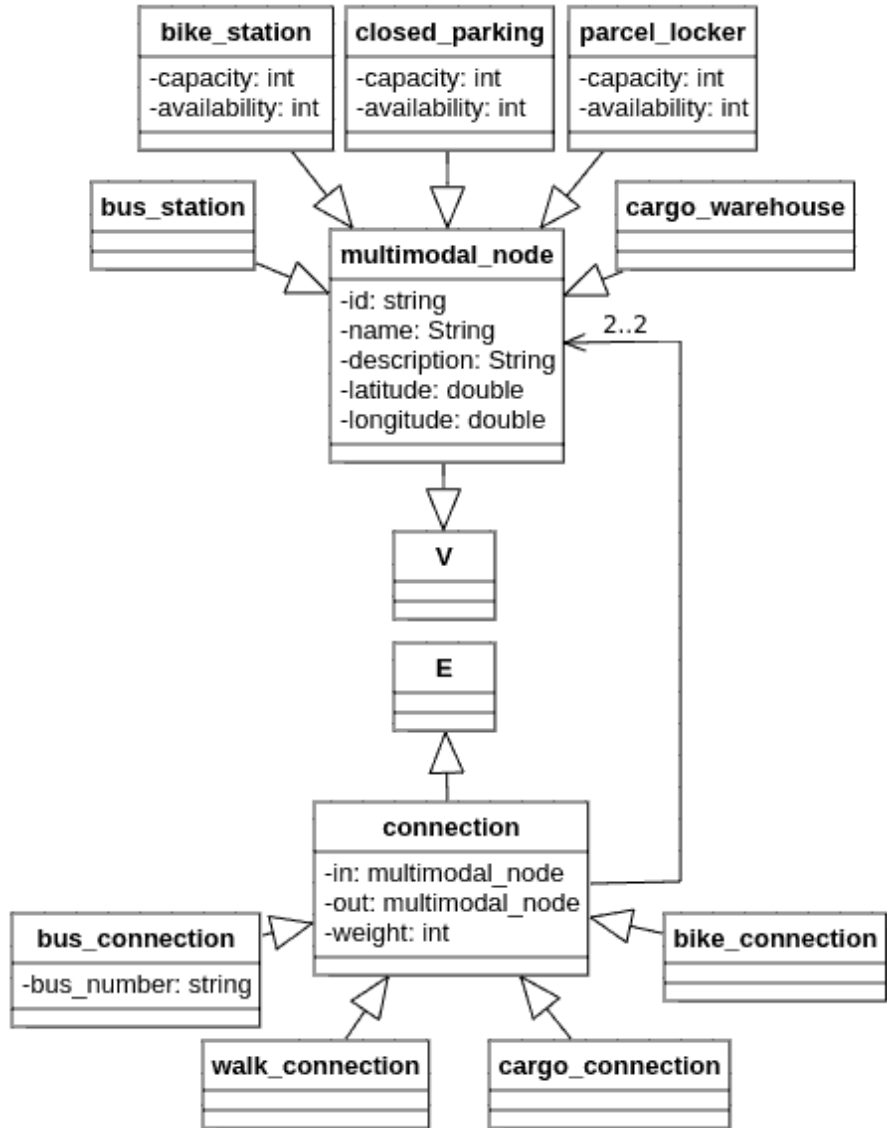
Selected database technology

▶ Choosing OrientDB key advantages:

- ▶ **hybrid model**, allowing for a blend of graph, document, object, and key/value models in a single application.
- ▶ **flexible schema** supports both strict and evolving data models.
- ▶ **SQL-like query language**, grounded in familiar SQL syntax, enhances ease of use.
- ▶ Its **open-source** nature under the Apache 2 license presents a cost-effective solution.

- ▶ Neo4j
- ▶ DEX
- ▶ Infinite Graph
- ▶ Infogrid
- ▶ HyperGraphDB
- ▶ Trinity
- ▶ Titan

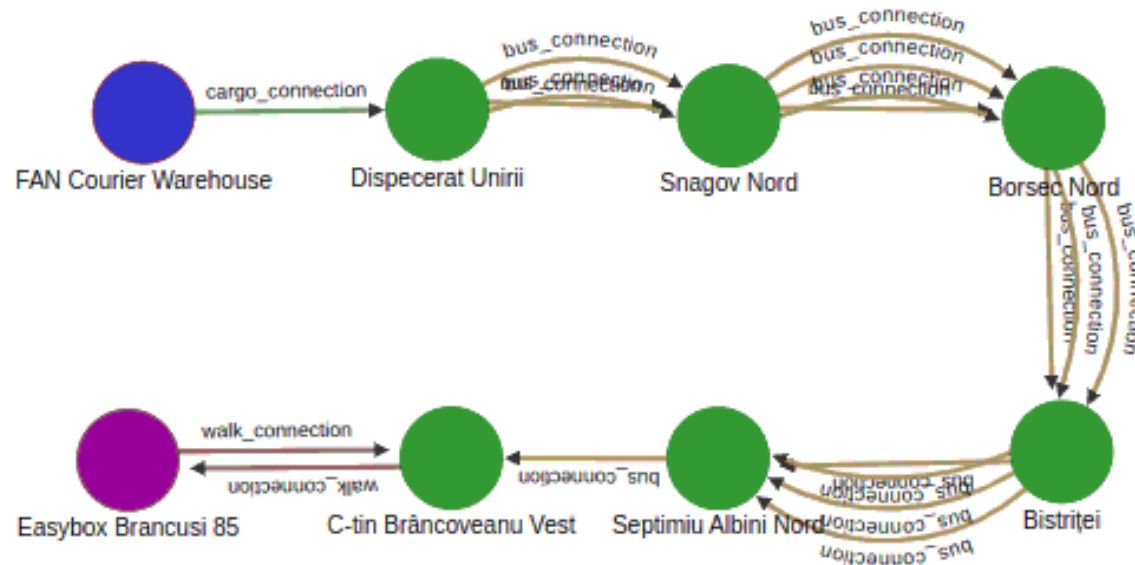
Proposed Graph Data Model



- ▶ The model defines a base node class, *multimodal_node*, that contains the common attributes of all the other node types in the graph: *id*, *name*, *description*, and the geographical coordinates (*latitude* and *longitude*).
- ▶ *multimodal_node* is further extended by concrete nodes: *bus_station*, *bike_station*, *closed_parking*, *cargo_warehouse* and *parcel_locker*. The classes *bike_station*, *parcel_locker* and *closed_parking*, apart from the inherited attributes, have two other attributes: *capacity* and *availability*.
- ▶ Regarding the edges, the model contains a base, namely *connection*. The concrete edge types are: *bus_connection*, *walk_connection*, *cargo_connection* and *bike_connection*.

Query Examples (1)

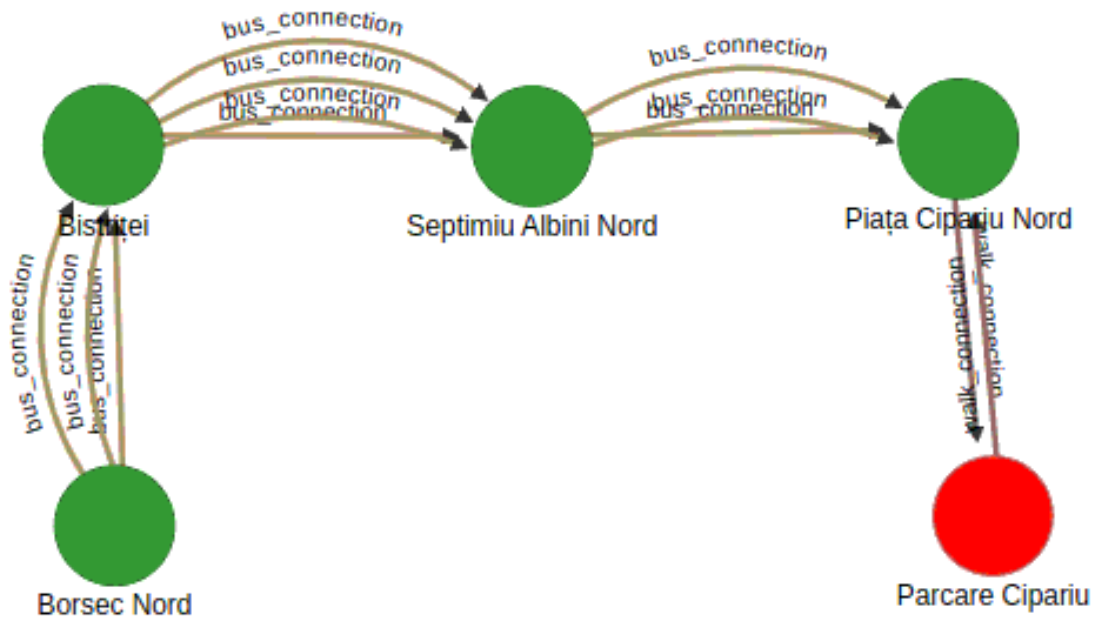
```
SELECT expand(path) FROM (  
  SELECT dijkstra($from, $to, 'weight') AS path  
  LET  
    $from = (SELECT FROM multimodal_node WHERE name='FAN Courier Warehouse'),  
    $to = (SELECT FROM multimodal_node WHERE name='Easybox Brancusi 85')  
  UNWIND path  
)
```



Shortest path between the warehouse and parcel locker

Query Examples (2)

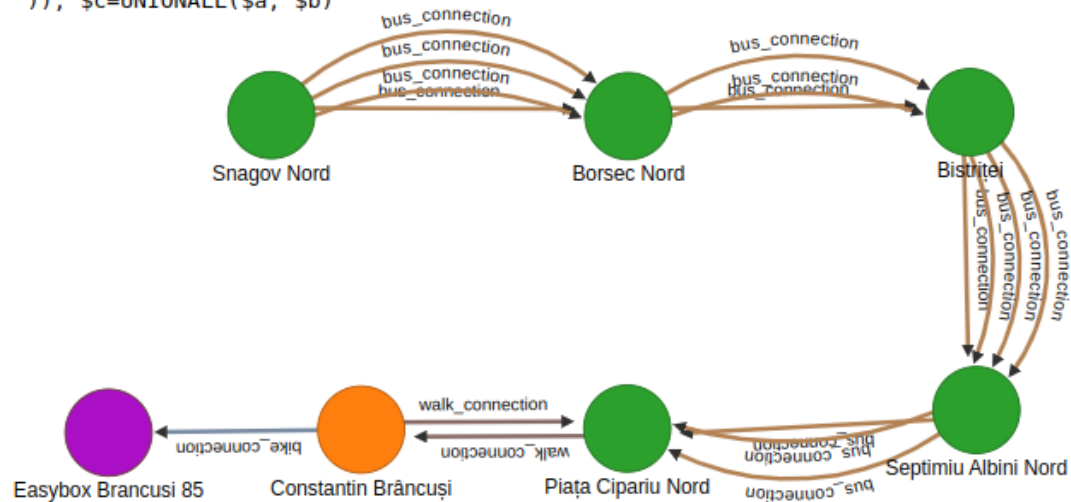
```
SELECT expand(path) FROM (  
  SELECT dijkstra($from, $to, 'weight') AS path  
  LET  
    $from = (SELECT FROM multimodal_node WHERE name='Borsec Nord'),  
    $to = (SELECT FROM multimodal_node WHERE @class='closed_parking')  
  UNWIND path  
)
```



Shortest path to the closest closed parking

Query Examples (3)

```
select expand($c)
LET
$a=(SELECT expand(path) FROM (
SELECT dijkstra($from, $to, 'weight') AS path
LET
$from = (SELECT FROM multimodal_node WHERE name='Snagov Nord'),
$to = (SELECT FROM multimodal_node WHERE name = 'Constantin Brâncuși')
UNWIND path
)), $b=(SELECT expand(path) FROM (
SELECT dijkstra($from, $to, 'weight') AS path
LET
$from = (SELECT FROM multimodal_node WHERE name = 'Constantin Brâncuși'),
$to = (SELECT FROM multimodal_node WHERE name = 'Easybox Brancusi 85')
UNWIND path
)), $c=UNIONALL($a, $b)
```



Last mile delivery solution

Conclusions

- ▶ The adoption of graph databases **offers a robust solution** for managing the complexities inherent in multimodal transportation networks.
- ▶ This approach has advantage of relational database models by providing more **intuitive and efficient methods for data representation and querying**, especially in **systems characterized by many-to-many relationships** and network-like structures.
- ▶ The practical application of the proposed graph database model in the public transport network of Cluj-Napoca highlights the potential of this approach in real-world scenarios.

Thank you!



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