

Vessel's Identity Graph and analysis

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Maritime mobility data is an inexhaustible source of information that can be used to enable the navigators and surveillance stations to have a comprehensive understanding of the maritime situation in real-time. Adequate models and analysis of historical maritime data can also favor advanced **knowledge extraction** for a **deeper understanding** of trajectories, routes and worldwide maritime networks along space and time. In this work, we are interested in the modelling of **maritime patterns of life**. Having a focus on the life cycle of the **ship's identity**, we propose a graph model and its implementation on the Neo4j graph database. Several Cypher queries are applied to illustrate the potential of the model.

Objectives

- ❖ Formalise activity and life cycle of a vessel and the different relationships with an adequate model for their representation
- ❖ Extract identities of interest: behavioural and anomalous activities and life cycles in space and time
- ❖ Apply operational analytics to the patterns and activities in space and time

Vessel's identity graph model

- ❖ A graph model is used for vessel's identity representation
- ❖ Different nodes and edges, annotated with spatial, temporal and semantic attributes

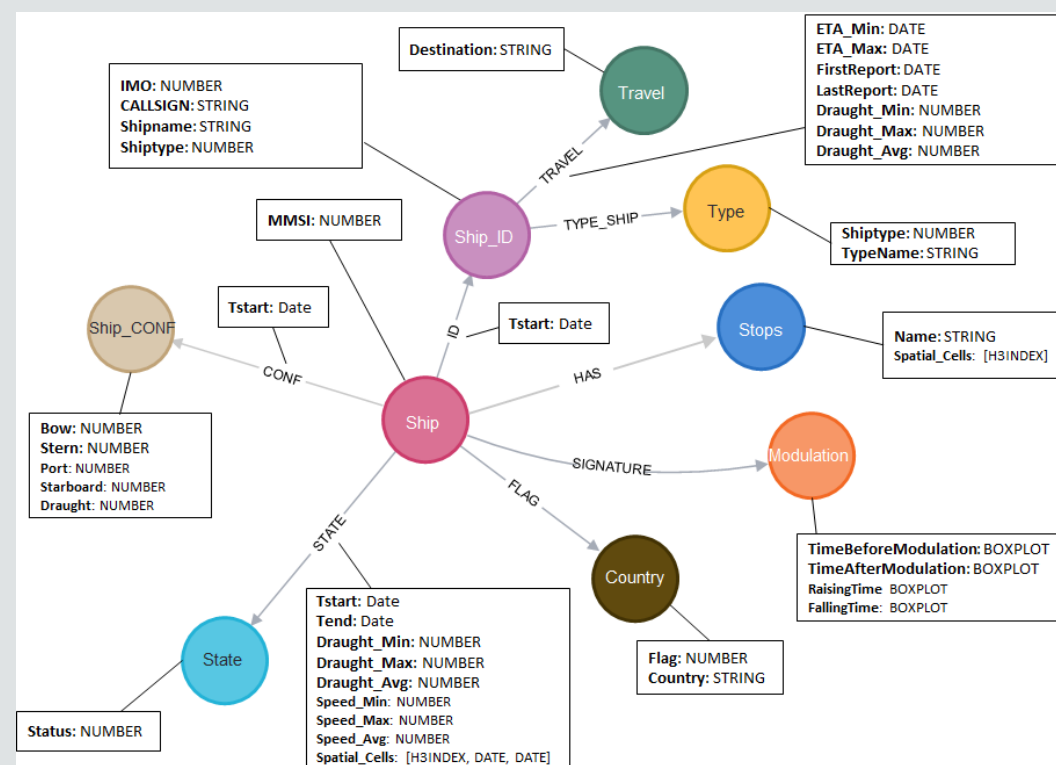


Fig. 1 - Graph schema of the Vessel's Identity Model

Spatial representation

- ❖ Spatial component is crucial for the identity representation and analysis
- ❖ Raw coordinates are not efficient for spatial analysis
- ❖ Hexagonal space representation is used within an Uber H3 indexes to annotate statuses and stops on the way

Vessel's identity analysis

- ❖ Vessel's Identity graph extraction from a query analysis: normal and anomalous identities in space and time

Cypher query for question "Which military ship appeared on 10/20/2015 at 5:53:27 ?"

```
MATCH (shipID:Ship_ID)-[id:ID]-(ship:Ship)
[conf:CONF]->(confShip:CONF_Ship)
WHERE ship.mmsi = "999999999"
AND toInteger(conf.t)>1445320407+3000
AND toInteger(conf.t)<1445320407-3000
AND id.t>1445320407+3000
AND id.t<1445320407-3000
RETURN ship,confShip,conf,shipID,id0
```

Fig. 2 – Cypher query for identity graph extraction

- ❖ Querying the vessel's identity graph in order to extract a vessel's identity of interest
- ❖ The ship declared with the identity "999999999" shows an anomaly as it had two configurations "Ship_CONF" at the same time

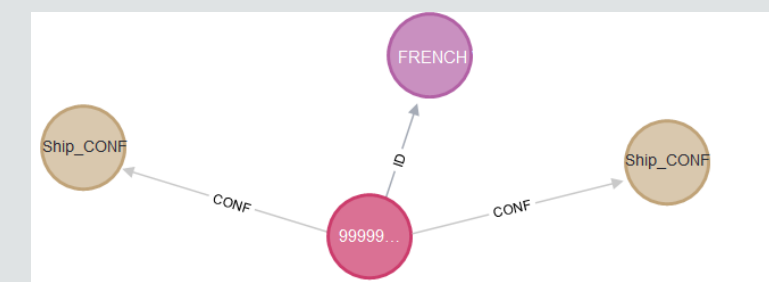


Fig. 3 – Identity sub-graph for the ship "999999999"

- ❖ Extraction of identity statistics, transformed as visual operational analytics, showing the distribution of vessel's statuses, destinations

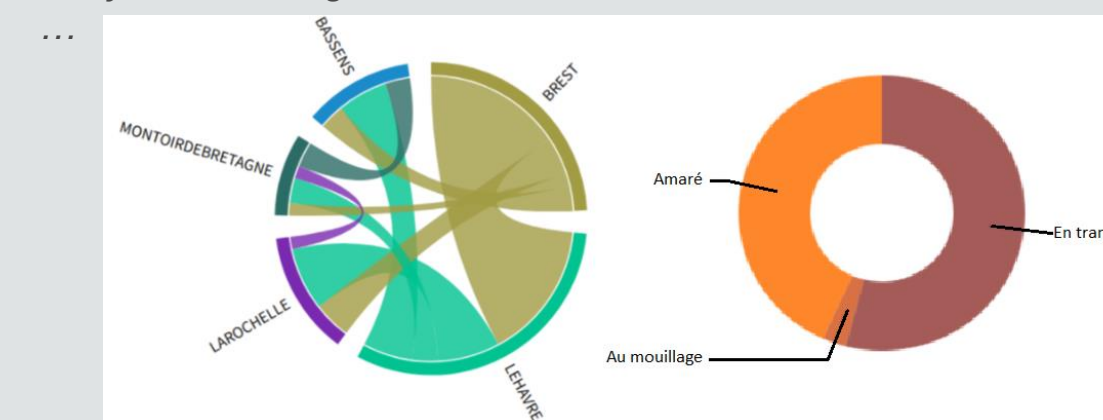


Fig. 4 – Resulting identity statistics chord (left) and donut diagram (right) showing flows between ports and distribution of statuses