A scalable data support model for traffic simulation in GIS

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1. INTRODUCTION

Network modeling and analysis have become a real practical problem in the continuing growing cities. Facing daily traffic and its impact on the environment and society behavior are nowadays issues calling for suitable solutions. To achieve this we rely on *Geographical Information Systems for Transportation* (GIS-T). A GIS-T must be capable to store, manage, process, retrieve and display network and traffic information gathered from multiple resources as more accurately and closer to reality as possible, yielding to the necessity of an adequate data model to fulfill these requirements.

One of the most popular approaches in GIS-T modeling is the *arc-node* view. In respect to this model Goodchild (2000) identifies some problems:

- The indispensability of lane level road segments definitions.
- Intersections issues such as, roundabouts and intersections that does not cross physically.
- No multimodal routing available.
- Redundancy, since street names must be repeated for each *arc*.

Moreover, Miller and Shaw (2001) emphasize that for a data model to maximize data integrity when deployed as a database the arc-node network often requires *planar embedding*.

These problems affect the exactitude and certainty in which data is modeled thus generating inaccurate simulations and results. In pursuance of real life applicable solutions it is indispensable to address these issues.

2. THE ARC-NODE VIEW AND THE LINEAR REFERENCING SYSTEM

Goodchild (1992) establish two stages for arc-node definition. In the first stage the network is created with nodes and arcs. In the second stage, further information as gas stations, traffic lights, etc., is embedded into the network. This data may be expressed as the tuple $T = < l, o, z_1, z_2, \dots , z_n >$ where l stands for the *link* which data is connected to, whether a node or an arc, o is the offset from the origin of the link, and z variables represent the properties of the object being modeled. Have as example a speed limit sign. In this case, the link would be a road, the offset could be the milepost at which the object is placed, and a property could be an integer value for the speed limit. This process for constructing a network and locate objects is also known as *Linear Referencing System* (LRS) (Blazek 2004, Miller and Shaw 2001).

For our traffic simulation purposes this arc-node model is incomplete, and must be extended to provide us with all the functionalities expected.

3. THE PROPOSED MODEL

In Figure 1 the Network data model designed is depicted.

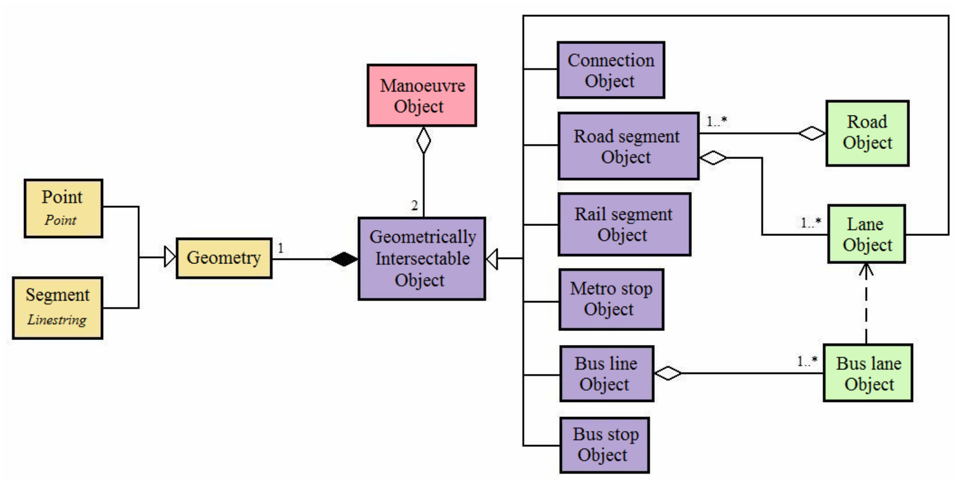

Figure 1: Structure of the Network data model proposed.

First is the *Geometry*. It can be either a *Point* or a *Segment*. The Point is represented by the OGC spatial object *Point* (OGC Reference model 2009). The Segment is denoted by the OGC spatial object *Linestring*.

Second follows the *Geometrically Intersectable Object* (GIO). The GIO is composed of exactly one Geometry, hence it is accepted as parameter in the spatiotemporal function *ST_Intersects(Geometry,Geometry)* from here the term intersectable is suggested. A GIO can take the following forms:

- *Connection object:* A simple segment with no type.
- *Road segment object:* A segment that represents a part of a road.
- *Rail segment object:* A segment that stands for a part of a railway.
- *Metro stop object:* A point denoting a metro station.
- *Bus line object:* A set of *Bus Lanes*.
- *Bus stop object:* A point that match with a point in a Bus line.

Third, *Manoeuvres*. A Manoeuvre allows a route between GIOs, which means it is possible to travel from one GIO to another verifying that those geometrically intersect using the functions ST_Intersects maintaining in this way the data integrity. In a roundabout for example, the incoming Road segments do not cross each other, but there is a Manoeuvre from that permits the connections as illustrated in Figure 2.

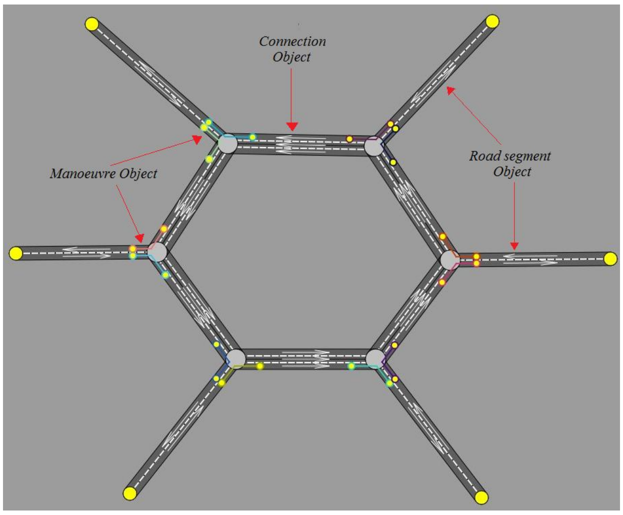

Figure 2: Roundabout showing how Manoeuvres connects different GIOs.

With the specified Manoeuvres it can found a route from network elements that do not geometrically intersect, but there exist a successive chain of GIO elements that enables a path between them.

Connection objects would rather be used in small pieces, such as shown in Figure 3. In this case these enable a route from a Road segment to a Metro stop. This is applicable if a pedestrian simulation is desired. Consequently, Connection object solve the multimodal routing problem.

(a) (b)

Figure 3: Sao Joao hospital zone in Porto, Portugal.

(a) In green, the rail segment on which the metro city travels. In blue, Sao Joao and I.p.o. metro stations.

(b) The small connection objects that enable a path from a road segment to a metro stop are illustrated.

The *Road object* is intended to solve the redundancy problem by constructing a whole *Street* taking a set of Road segments. In that manner the street name appears just once as Road object property and not in every Road segment. Finally the *Lane object*. Lanes use the Road segment's geometry corresponding. Thus, it is possible to construct lane level Manoeuvres and still guarantee these will be crossing in the real-world.

4. RESULTS

This model was implementing using the ORDBMS PostgreSQL in conjunction with the spatial database extension PostGIS. Data was exported to traffic simulators such as DRACULA (Liu 1994) and *SUMO* (Krajzewicz et al. 2002), as exposed in Figure 4 and Figure 5.

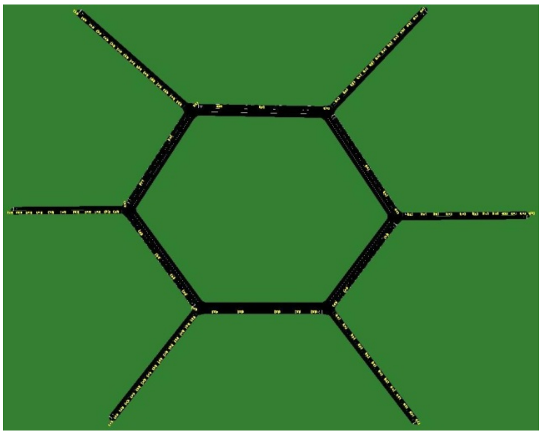

Figure 4: Example of a roundabout simulation in SUMO.

Figure 5: Example of a part of Porto city network simulation in SUMO.

5. CONCLUSIONS

The proposed model creates a more detailed data representation, maintaining consistency, integrity and accuracy of the collected data. The model can still be extended to increase the multimodal routing features available. The idea in data network modeling when applied to simulation is to go as farther and accurate as possible applying exhaustive methods for processing information, with the very last intention of create a rich data model that help to understand the underlying problem of traffic city network in society.

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