Spatio-Temporal conceptual model for a WEEE GIS application

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Abstract. *This project focuses on optimizing the location of WEEE collection points for waste electrical and electronic equipment (WEEE) which consists of determining a set of locations to install a network of gathering equipment. It is implemented using open source technologies following the current tendency of the present software market situation. In particular, the software application to be developed will provide a visual way to control an entire logistics network of WEEE collection and sorting points. The implementation of this cutting edge proximity, availability and easy access to producers of waste (individuals and others), will increase the amount of WEEE collected and consequently environmental benefits of reducing poor waste disposal. Several Java algorithms are being developed in order to solve location and vehicle routing problems. It can also lead to important reductions in operating costs in the transportation, storage or sorting levels and contribute for reductions in pollution and energy consumption levels.*

Keywords. *GIS, WEEE, Reverse logistics, Spatio-temporal modeling, Location problems, VRP, vehicle routing problems, Open-source software, web-based application.*

1 Introduction

This project is for the particular case of Amb3E- Associação Portuguesa de Gestão de Resíduos de Equipamentos Eléctricos e Electrónicos (Portuguese Association for the Management of Waste from Electrical and Electronic Equipment) a non-profit association under private law, which on March 13th 2006 received its licence from the Minister for Economy and Innovation and the Minister of the Environment and Territorial Planning [1]. This licence gave it the right to manage electrical and electronic waste in Portugal, distinguishing it as a type of WEEE reverse supply chain management company. The logis-

tics associated with the collecting operation of WEEE imply a decision about the locations of facilities and capacity of services, such as the transportation required for effective and efficient use of waste EEE collecting points and central sorting facilities (CSF). In order to better understand and analyze the geographical dynamic characteristics of a GISWEEE (Geographical information System for Waste electric and electronic equipment), there is a need for a GISWEEE with temporal capabilities. This can be accomplished by using spatio-temporal data models, database management systems and other information systems [2].

2 WEEE logistical system

2.1 Description of the supply chain

The growing demand for applications for geospatial information systems and dynamic modeling led to the development of spatio-temporal database management systems in computer science [3]. In the Amb3E case (Figure 1), the consumer has different places to deposit their old EEE, which can be seen as the collecting points for EEE over a widespread area. The equipment deposited at the different collecting points is gathered by the waste collector vehicles of a logistic operator which in turn transports the goods to a CSF. The direct route EEE collecting points (some are transfer stations), are typically linked by point to point types of transportation in which the transport is made directly to a gathering center. In some special cases, there is the possibility to transport the EEE directly to the re-processing unit. The other EEE collecting points are scattered and do not follow a typical filling pattern, so these points are a typical problem for the vehicle routing solution.

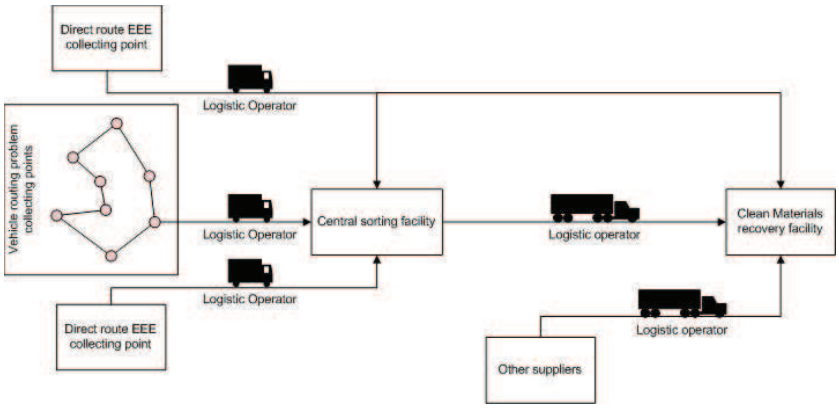

Figure 1: Reverse WEEE supply chain system.

The equipment is weighted, separated according to its operational flow categories (ten categories according to volume and typology criteria), and stored for transportation. When circumstances permit, a logistic operator transports the separated EEE again by a logistic operator to a re-processing unit. The re-processing unit will remove the dangerous substances and strip the EEE components for the forward supply chain unit (production or distribution) or the disposal facility.

2.2 Spatio-Temporal problems: Location and VRP

The main problems that arise from the supply chain described before are related to location and vehicle routing problems. The location and vehicle routing problems are divided into three major problems: 1) minimization of distances, 2) maximization of service and 3) maximum coverage. These problems can be supplemented with additional restrictions that provide limits to the maximum capacity and maximum distances between depots and customers. Given the wide variety of EEE in terms of physical characteristics (weight, volume, etc.) and the final destination, it might be advantageous the existence of accumulation points of WEEE to optimize the cost of transport to the recovery centers. In fact, in many situations, transport costs can be significantly reduced if the volume of cargo to be transported is considerable, allowing the use of means of transport more economically efficient.

3 Architecture analysis

The system architecture and the software components of this application were designed to control different fleets of waste collector vehicles, from different logistic operators, between several collecting and CSF points, and consequently between the reception point and consolidation/reuse point within a client-server type architecture [4]. It is a service supply oriented architecture, which creates the integration and chaining of several services by processing the geospatial data distributed through the Web. The geospatial positions are available in Amb3E by means of information stored in a historical database. Therefore a spatio-temporal data modeling in GISWEEE is needed to show and analyze space-time information. We can distinguish the cartographic maps, roads, utilities, etc, that do not typically change in a short period of time as a static spatio-temporal data information model. Even though the locations of the geospatial objects are static (Figure 2), their attributes may change over a short period of time making this a model of dynamic spatio-temporal data information [3].

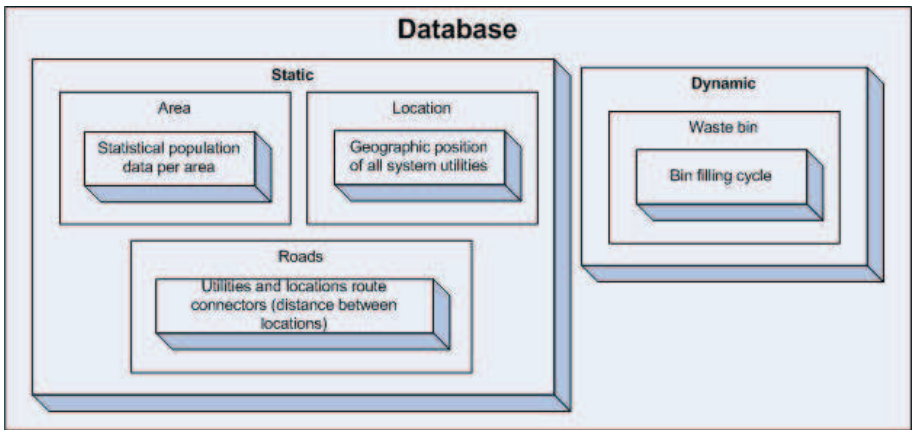

Figure 2: GISWEEE system integration with spatio-temporal static and dynamic database.

3.1 Spacio-Temporal GIS design

The main building blocks that make a typical GIS are databases, its visualization and analysis (Figure 3). In the database, the historical and real time data, such as bin retrieval, time duration, and flows (types of EEE), are stored for analysis or visualization. Dynamic visualization shows the system by means of animations or 2D representation. To find an optimal route or location for a given area in this system, an operational management or strategic analysis is requested, considering the updated information in the temporal database and the static spatio-temporal static information database [3].

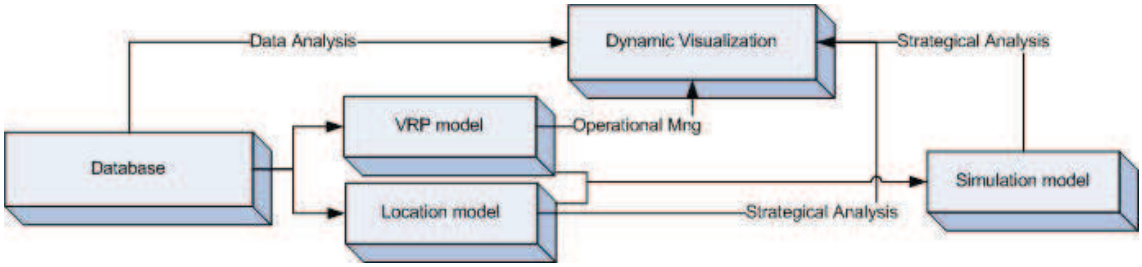

Figure 3: GISWEEE temporal relationships between the temporal database, temporal analysis and temporal visualization.

3.2 Technologies

By using the Google Web Toolkit, we will be able to provide the user with a group of tools for the handling of maps and some GIS operations (route distances, visualization, etc), that are similar to or better than some present professional software tools for handling the GIS. As we said above, this group of tools is implemented on free or open source software platforms. The web applications are run under a Glassfish 2v server, and it uses MySQL as a database agent. The algorithms have been implemented on a Java IDE platform like Netbeans and Eclipse. It will also have the ability to use a Business Intelligence and Reporting Tool, such as JasperReports for the generation of dynamic reports.

4 Conclusion

There are a number of free software GIS which include viewers, libraries and complete systems. In fact there are several projects which emphasize the visualization of geographic information like Google Maps or Yahoo! Maps. The project aims to contribute to better economic and environmental performance for the national WEEE, notably through the rationalization of the logistics involved in the collection and recovery of WEEE managed by this company (one of two management companies operating in our country).

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