Chapter 15
Cooperative Inter-Municipal Waste Collection:
A Multi Agent System Approach

Vitoantonio Bevilacqua
Politecnico di Bari, Italy

Francesca Intini
Università della Basilicata, Italy

Silvana Kühtz
Università della Basilicata, Italy

Paolo Renna
Università della Basilicata, Italy

ABSTRACT

The cooperative inter-municipal waste collection can be a real added value in terms of costs reduction and high performance services. The chapter proposes a Multi Agent Approach to support the inter-municipal infrastructure. The Multi Agent Systems (MAS) is an approach suitable to implement a distributed physically problem as the inter-municipal waste collection. The architecture of the approach is formalized by work-flow analysis: a static view by IDEF0 diagram and a dynamic view by UML activity diagram. This analysis promotes the cooperation among municipalities to manage the waste collection service in an optimal way. According to Italian laws, the municipalities are responsible for organizing the management of municipal waste in agreement with the principles of transparency, efficiency, effectiveness and inexpensiveness. The coordination protocol among the agents allows to divide the costs among the municipalities in an efficient way. Finally, a discrete event simulation environment is developed to test the proposed MAS architecture.

DOI: 10.4018/978-1-61520-981-1.ch015

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INTRODUCTION

A municipal solid waste (MSW) management system is a very complex system: there are multi-objectives to be achieved. Planners must develop the best practicable and environmentally sustainable waste management strategies and this task could be very difficult to carry out. The different objectives are not all related to economic costs and must therefore be considered in a proper multi-objective framework.

In this chapter we have carried out a study in order to estimate and allocate the costs related to separate waste collection in an inter-municipal area located in the province of Bari (Italy). This analysis promotes the cooperation among municipalities to the waste collection service management. Actually the municipalities are responsible to waste collection in accordance with principles of transparency, efficiency, effectiveness and inexpensiveness.

For this reason we have built a model of separate waste collection management, highlighting the cost functions, based on Multi-Agent Theory (Li, 2006; Xiao, 2006). MAS is an approach suitable to implement a distributed physically problem as the inter-municipal waste collection. The search of waste collection path can be interpreted as a Travelling Salesman Problem TSP and it is solved with the use of genetic algorithms. The total cost of the service has been divided among the individual municipalities using the theory of cooperative games, stressing that local authorities are not interested in paying off more than they would pay if they were organized independently. The proposed simulation environment has been developed using the Java package and it can be used to support the decision of a municipal area to participate in a network.

In summary, the chapter deals with:

- The formalization of the MAS architecture, obtained using the IDEF0 and UML diagrams. The former describes the processes' static view, including inputs, outputs, controls and mechanisms. IDEF0 diagrams allow us to describe static view, while UML activity diagram the dynamic views of the MAS architecture.
- The cooperative approach proposed allows integrating several municipal areas through the MAS architecture. The innovative aspects concern two levels:
- At level of waste collection organization, the approach allows to adapt to real production waste rate by varying the waste collection frequency for each kind of waste.
- At computational level. The MAS architecture knows in quasi real-time the real state of the containers, therefore the TSP problem can be reduced.
- The simulation environment, based on a multi-agent architecture. The information provided by the simulation environment leads to a quantitative evaluation about the best strategies to be used by agents and the advantage for the municipal areas participating to the cooperative approach.

The conclusions can be located at two levels: design and operative. At design level the proposed approach is based on three kinds of technologies that, to the authors' best knowledge, are essential for added value services developing: agents, work-flow management techniques and open source IT tools.

At operative level the research underlines how, through the development of a simulation environment, real added value can be evaluated and the real costs reduction for the participants achieved.

BACKGROUND

In the last decade, waste management issues have gained importance. The production solid waste (MSW) in Italy has increased considerably: between 2003 and 2007 the volume of MSW in-

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