PhD Open Days

Waste collection based on a real-time route planning system

ENGINEERING AND MANAGEMENT

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Problem

A high uncertainty is associated to the waste accumulation and a “blind collection” operation is performed: all bins are visited through static and pre-defined routes without knowledge of their actual fill-level. Waste collection operations are related to high inefficiency where several kilometres are travelled to often collect only small amounts of waste.

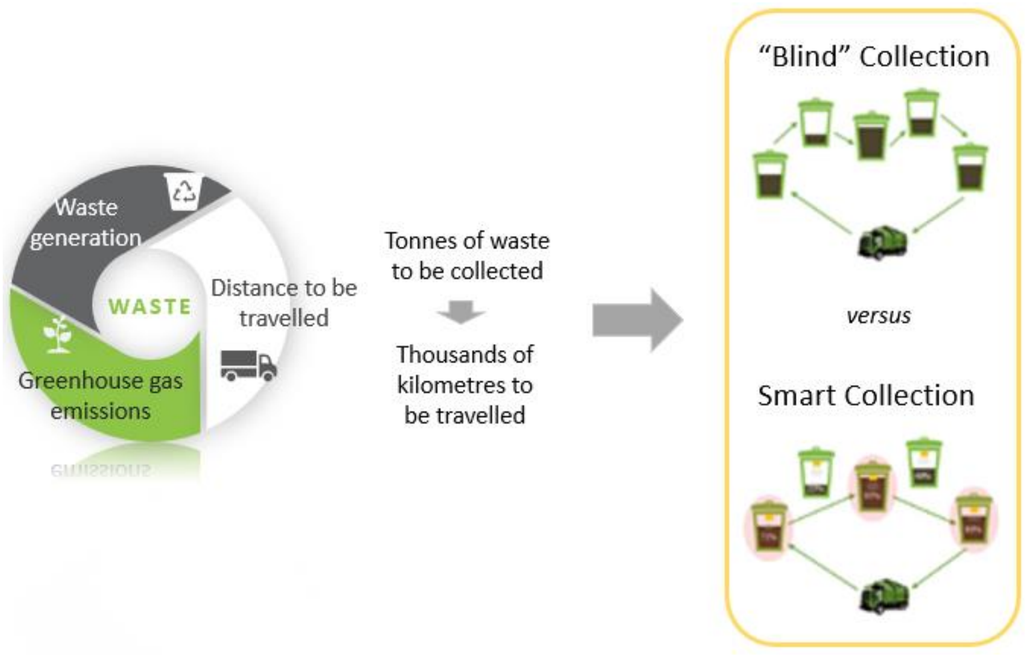


Figure 1: Blind *versus* smart waste collection

Objective

To develop an innovative dynamic tool for smart waste management aiming to improve the quality of the operational decisions in the waste collection business.

Solution

The Smart Waste Collection Routing Problem (SWCRP) considers volumetric sensors, placed inside the waste bins, to transmit real-time information on its fill-level and defines smart collection routes that maximize the collected waste while minimizing the travelled distance.

Approaches

To solve the SWCRP, different approaches are explored:

1) SHORT-TERM APPROACH:
A Vehicle Routing Problem with Profits (VRPP) model is solved every day, maximizing daily the amount of collected waste while minimizes the total travelled distance. However, this approach cannot consider the days ahead, so it is blind for future events.

2) STATIC MEDIUM-TERM APPROACH:
To guarantee a profit maximization for the entire planning horizon, a static Inventory Routing Problem (IRP) model is solved at day 1, considering the entire planning horizon. However, this approach considers real-time information only for the 1st day of the planning horizon, dealing with estimates for the days ahead.

2) DYNAMIC MEDIUM-TERM APPROACH:
To maximize profit over the entire planning horizon allowing a continuous data updating in the model, the static IRP model is embedded into a Rolling Horizon framework: the model is solved every day, considering an active partial planning horizon. For all iterations, the resulting plan for the current day is fixed for the next iteration, which will be carried out at the next day, using the new available real-time information.

Results

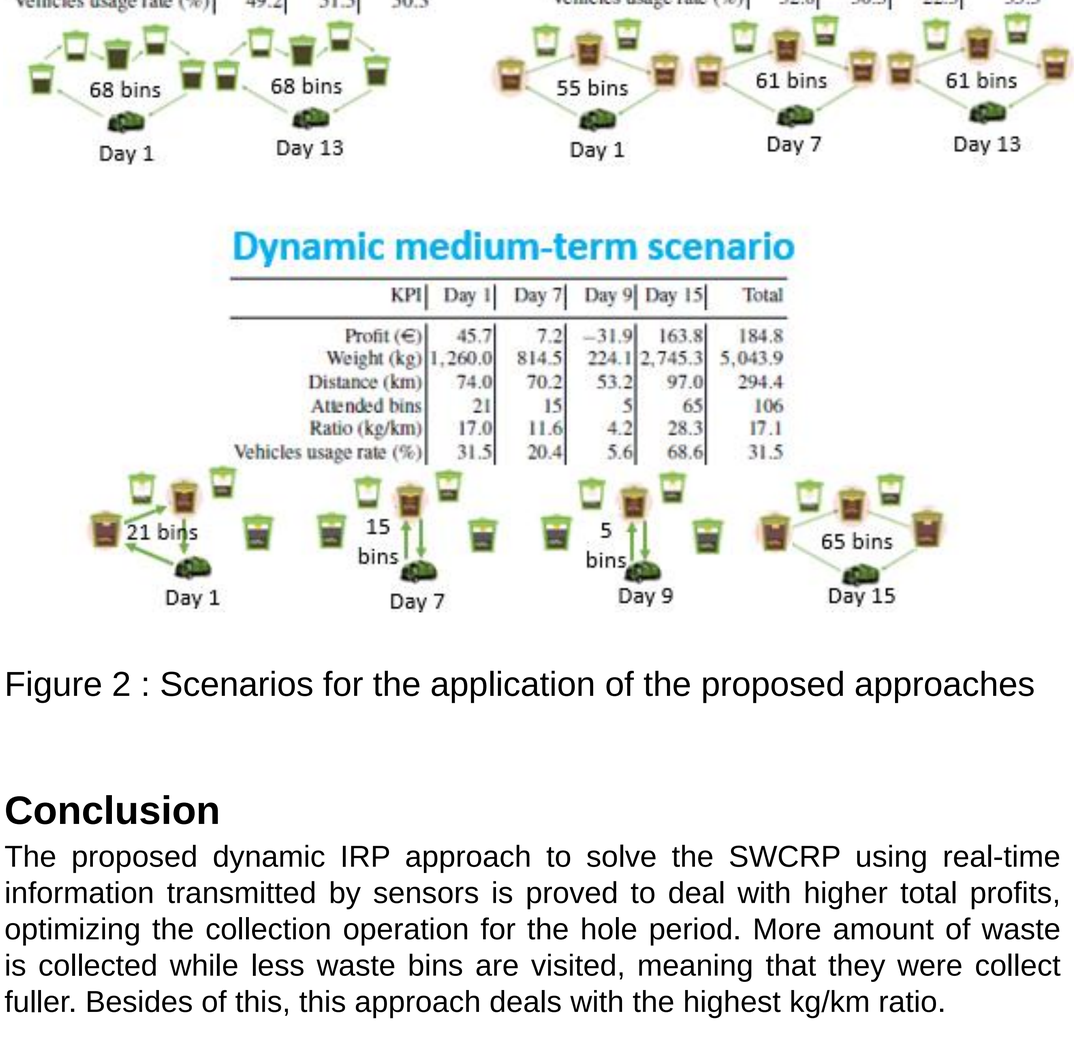
Applying the proposed solution approaches to data from a Portuguese recyclable waste collection company, different scenarios are defined:

Current scenario

KPI	Day 1	Day 13	Total
Profit (€)	51.0	60.1	111.1
Weight (kg)	1,966.4	2,062.3	4,028.7
Distance (km)	135.8	135.8	271.6
Attended bins	68	68	136
Ratio (kg/km)	14.5	15.2	14.8
Vehicles usage rate (%)	49.2	51.5	50.3

Short-term scenario

KPI	Day 1	Day 7	Day 13	Total
Profit (€)	114.9	24.2	23.4	162.5
Weight (kg)	2,113.5	1,221.3	1,203.8	4,538.6
Distance (km)	85.9	91.8	91.0	268.7
Attended bins	55	61	61	177
Ratio (kg/km)	24.6	13.3	13.2	16.9
Vehicles usage rate (%)	52.8	30.5	22.5	35.3



Dynamic medium-term scenario

KPI	Day 1	Day 7	Day 9	Day 15	Total
Profit (€)	45.7	7.2	−31.9	163.8	184.8
Weight (kg)	1,260.0	814.5	224.1	2,745.3	5,043.9
Distance (km)	74.0	70.2	53.2	97.0	294.4
Attended bins	21	15	5	65	106
Ratio (kg/km)	17.0	11.6	4.2	28.3	17.1
Vehicles usage rate (%)	31.5	20.4	5.6	68.6	31.5

Figure 2 : Scenarios for the application of the proposed approaches

Conclusion

The proposed dynamic IRP approach to solve the SWCRP using real-time information transmitted by sensors is proved to deal with higher total profits, optimizing the collection operation for the hole period. More amount of waste is collected while less waste bins are visited, meaning that they were collect fuller. Besides of this, this approach deals with the highest kg/km ratio.