SECURITY PROBLEMS OF WASTE LOGISTICS IN FOOD TRADE

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Abstract: In the first two chapters of the paper, the model of waste logistics applied for the food trade sector is presented, along with the specification of the main elements of the system. This is followed by a qualitative definition of the applicable objective functions for optimization, while in chapter 4 the architecture of the database of the model is presented. Finally the last chapter describes the future direction of the analysis.

Keywords: waste logistics, food trade, optimization, security

Introduction

Nowadays the turnover of food products is realized through the use of network-like logistical systems. The needs of the customers are formulated on the basis of regional aspects, in a unique and rapidly changing fashion. One of the most important and constantly present aspect of satisfying the customer requirements is the marketing of food products within their warranty time. While this is not always possible, nevertheless the marketing of expired warranty products has to be prevented. This can be achieved with the up-to-date registration of the warranty periods, together with the collection and neutralization of the expired warranty products. Completing this task requires network-like recycling logistics activities, in which the efficiency and security of waste collection plays a significant role.

1. Definition of the task

Product warranty plays a dominant role in food trade, as it defines strict marketing and utilization periods for the different products. It follows that the collection and elimination of the large amounts of expired warranty products on a country level presents itself as a serious problem. A number of connected logistical tasks have to be solved on a day-to-day basis:

- up-to-date registration of the expired warranty products at the different sources (shops, stores, restaurants, etc.),
- planning of daily collection routes based on the volume and geographical distribution of the waste products, as well as on the available transport capacity,
- implementation of the task on a country level,
- precise warranting of the waste products from the point of takeover to the point of neutralization.

2. Creation of a model for the analysis of the defined task

A logistical model has to be created in order to analyze the previously defined task. During the creation of this model the following system components have to be specified:

- impoundment and characterization of the network under examination,
- sources of the expired warranty food products (shops, stores, restaurants, hospitals, etc.), referred to as sources in the following.
- facilities used for the neutralization and recycling of waste products, later referred to as receivers (composting plants, biogas plants, waste depots, etc.),
- bases for the vehicles used in the collection routes, later referred to as bases,
- different types of vehicles, referred to as vehicles in the followings,
- categorization of the different waste products based on the methods of their handling, later referred to as waste categories,
- categorization of the classes of unit load carriers (ULC) based on the transported waste category (typically different types of dumpsters),
- the transport network that is used for the realization of the collection routes (typically the road network),
- the information network that is used for assuring the communication between the various system elements.

Figure 1. represents the logistical model based on the previously listed elements (for the purpose of better transparency, only the three main system components and their connections are visualized). The markings in the figure have the following meanings:

- S_i: parameter representing the sources, where $i = 1 \ldots n$,
- R_j: parameter representing the receivers, where $j = 1 \ldots m$,
- B_k: parameter representing the bases, where $k = 1 \ldots p$,
- continuous line: loaded run,
- intermittent line: unloaded run.

After defining the main components of the model, we have to describe them with their characteristic parameters. But first, the characteristic route types of the system are going to be presented. These are the followings:

- collection routes, which begin with an empty run from the given base to the first source in the route and ends with the return of the loaded vehicle to the base, after visiting several sources (the collected waste is temporarily stored at the base),
- shuttle services, which are functioning between the bases and the receivers. During these services, the vehicles transfer the previously collected waste to the receivers, then return to their origin unloaded,
- direct routes, which are characterized by the direct transfer of the waste products from the sources to a receiver, without visiting a base in the meantime.

Besides the previously listed items, another route type is possible, where the vehicle unloads the “cargo” on a base that is different from the vehicles home base. Then, it returns to its origin while visiting other sources in the meantime (this route type is rare due to the crew management problems related to it).
After the characterization of the possible route types, we can continue with the specification of the representative parameters for the system components. These are the followings, according to the individual components:

- Impoundment and characterization of the network:

- the physical extension of the network,
- the types of tasks which can be solved through the use of the network.

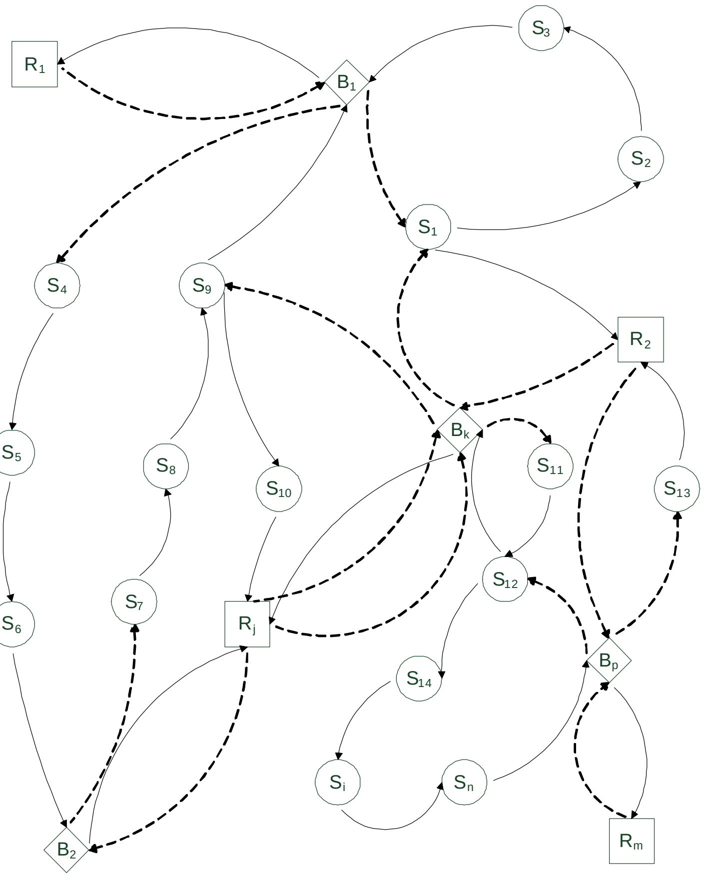

Figure 1. The general model of waste logistics in food trade.

- Sources:
  - the location parameters which define the position of the source in the network,
  - the waste categories which are present at the source,
  - the amount of nascent waste at the source, according to the different waste categories,
  - the frequency of visitation necessary for the source (usually defined by the customers),
  - the average waiting time at the source (usually needed for the loading of vehicles).
- Receivers:
  - location parameters,
  - the acceptable waste categories by the receiver,
  - the availability indicator of the receiver for a given time period,
  - the average waiting time at the receiver (usually needed for the unloading of vehicles).

- Bases:
  - location parameters,
  - the number of vehicles assigned to the base according to their types,
  - the temporary capacity for storing waste at the base,
  - the average waiting time at the receiver (the turning time of the vehicles).
- Vehicles:
  - types (generally trucks),
  - the number of transportable ULCs according to the vehicle type and to the individual ULC type,
  - the traveling speed of the vehicle,
  - the availability indicator of the vehicle for the given time period.
- Waste categories:
  - the transport requirements of the individual categories.
- ULC types:
  - the available quantities of each ULC type,
  - the transportable amounts of different waste categories according to the individual ULC types.
- Transport network:
  - class (typically the road network),
  - architecture,
  - the guaranteed traveling speeds on the individual sections of the network.
- Information network:
  - class,
  - architecture,
  - the information and data types which are handled by the system,
  - the flexibility of the system (the ability to react on unexpected situations).

3. The definition of the applicable objective functions for the model

In order to define the applicable objective functions, we have to take into consideration a number of criteria. These are the followings:

- the waste products to be collected are scattered on a large geographical area (significant diversification among the location parameters),
- according to the individual sources, the collection periods (which can be deduced from the visiting frequencies) are predefined,
- the vehicles are allowed to operate continuously only through a given time period, furthermore they have to return to their bases in a limited time frame (these are going to present themselves as boundary conditions for the objective functions),
- at the sources, the quantity of the nascent waste products changes in a stochastic way, which has to be considered during the route planning phase,
- the transport capacities of the different vehicles can vary,
- the individual vehicles can carry only specific types of ULCs.

In the aspect of the previous criteria, the applicable objective functions are going to be the followings:

- the capacity utilization of the applied ULCs has to be maximal,
- the material flow work done by the vehicles has to be minimal,

– the environmental impact, especially in the context of greenhouse gases emitted by the vehicles, has to be minimal (note that this is strongly related to the previous objective).

The following boundary conditions are going to be applied as well:
– all nascent transport needs within the given collection period has to be fulfilled,
– the realization time of the individual routes has to be under a given limit value,
– during the collection routes the requirements for security and product identification has to be completely fulfilled,

4. Developing the related database for the model

The structure of the database necessary for the optimization process is shown in the next figure:

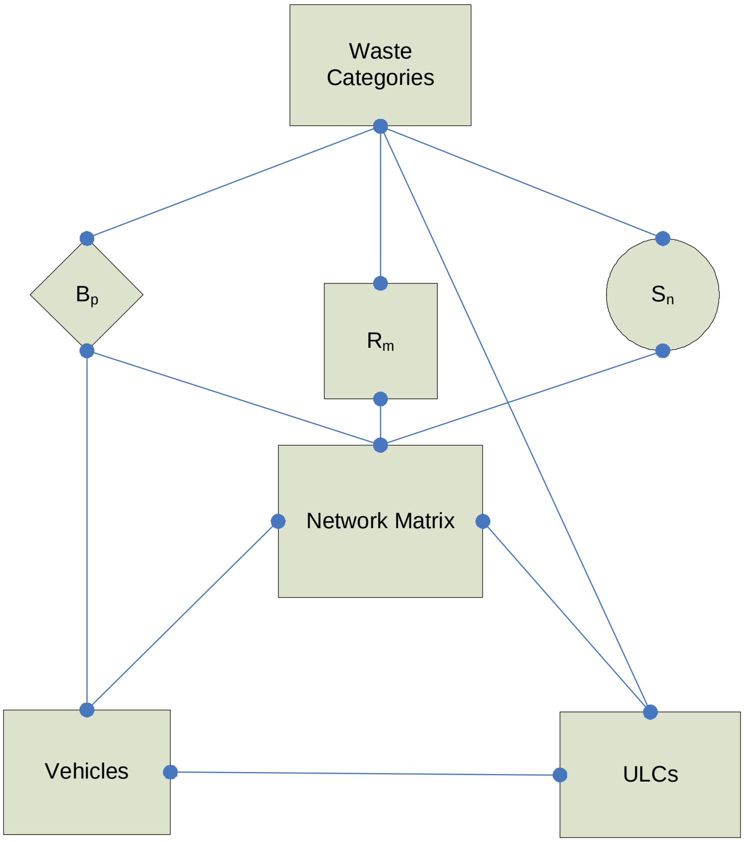

Figure 2. The architecture of the models database.

It can be seen that the main data types are derived from the component types of the system. The most important component is the network matrix, which is a formal representation of the applied transport network. Naturally both the sources, the receivers, and the bases of the transport enterprise (or enterprises) are linked to this matrix in accordance with their position in the network. The network matrix itself is a road matrix in its simplest form, consisting the shortest available travel distances between the previous components (sources, receivers and

bases). This structure can be the basis for route optimization, which is practically repeated on a day-to-day basis. At the same time we have to keep in mind that the road matrix is a formal representation of the physical road network and as such, its elements are affected by the physical changes in the latter (for example like road lockdowns).
If we would like to consider the problematic of adjusting the ongoing routes to the actual conditions (traffic condition, the actual amounts of nascent waste products, probable awaiting times, etc.) in a real-time manner, then we need to know the present states of the system components, such as the position of the vehicles. Including these parameters also into the database requires that the network matrix comprises all sections of the relevant road network, furthermore we need to know the actual states of the individual sections. These requirements clearly lead to a more complicated structure and possibly to the introduction of new data types.
It is apparent that the latter task also requires continuous data transfer between the system components. This is achieved through the use of the information system, which appears as a hidden factor and indirectly affects the qualitative and quantitative properties of the database (architecture, number of connections, renewal frequency of the data, etc.). Optimally, the information network is implemented with the use of internet based technologies, which are suggested even in those cases where only day-to-day route planning is needed. Naturally, the implementation of the fleet management functions requires modern vehicle telematics.

5. Conclusions and future direction of the analysis

On the previous pages of this paper, a qualitative model for the waste logistics of food trade has been presented. Furthermore, the objective functions for the model have been defined, which can provide the basis for the optimization of such systems, considering the boundary conditions derived from the economic and security criteria.
The model creates the possibility for the quantitative analysis of the problem. The first step in this analysis is the quantification of the component parameters. Also, the goals of the future analysis (concentrating solely on day-to-day route optimization, or also creating the optimal model for fleet management) has to be defined early, as it greatly affects the number of the component parameters and the overall complexity of the model. Another task will be the search for possibilities of simplification.
After the completion of the previous tasks, the mathematical description of the model can finally be done. Its main purpose will be the mathematical definition of the objective functions and the boundary conditions. The final goal is the creation of an optimization process, which serves as the basis for the economically effective operation of the system, while maintaining the proper levels of environmental safety and security during the operation.

References

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