A MultiCriteria Spatial WEB Decision Support System for Hazardous Materials Road Transport

Djamila Hamdadou, Emdjed Alnafie, Karim Bouamrane, Ikram Behilil
University of Oran, Ahmed BenBella
Algeria
dzhamdadoud@yahoo.fr
amazad15@gmail.com
kbouamrane@yahoo.fr
behilil@hotmail.com

ABSTRACT: *Oran road network is taken, daily, by thousands of vehicles, some of which are TDG (Transportation of Dangerous Materials). The latter have the characteristic of transporting substances may present a hazard to people, property or to the environment.*

Oran a city in Algeria, developing over the years, joined its industrial area which has urbanized ignoring the associated risks constraints.

Thus, its fuel storage center and distribution and its various service stations met the city. Therefore, this random extension, gave TDG roads "penetrating" the city.

This town characterized by narrow and stagnant roads, and an increase in traffic lives recrudescent accidental events of traffic.

The main objective of the current study is to design and develop a multi-criteria decision support system to identify the least risky paths according to a set of criteria assessed by experts in the field. In this context, a more specific objective is to provide a web application containing the developed decision support system and allowing carriers to check the system from their starting points.

Keywords: Web Decision Support System (Web DSS), Multicriteria Analysis, Geographic Information System (GIS), Technological Risk, Hazardous Materials Road Transport (HMRT) PROMETHEE II, ELECTRE I

Received: 10 September 2018, Revised 15 October 2017, Accepted 24 October 2017

1. Introduction

All roads and highways are potentially affected by the risk of hazardous materials transport. A substance is classified as dangerous when it is susceptible to cause serious consequences for people, property and / or the environment, depending on its physical and / or chemical properties, or by the nature of the reactions it can generate. It can be flammable, toxic, explosive, radioactive or corrosive.

The risk of hazardous materials transport is consequential of an accident occurring during transport by road track, railway, aerial, inland water way or pipeline of hazardous materials.

The role of a decision support system for the risk management is to provide the user a global view in terms of business continuity and risk management. In order to help the user to take good decision, this information should explicit different regions of interest from the point of view: information, documentation, regulation, contingency plan, prevention, incidents and emergency.

Certainly, in an accident, quantities of material that can be involved are much lower than in an accident at an industrial site, the affected area will be much smaller. However, accidents can happen anywhere in the territory, areas of high population density may be affected. This is, particularly, true for the agglomeration of Oran (a city in Algeria) through which passes a large tonnage of hazardous materials in addition to material flows generated by the activity of industrial sites located there, in this study we focus on the transport risk fuel.

The Oran road network is borrowed, every day, by millions of vehicles, among them some are Transport of Dangerous materials. They have the characteristic of transporting substances may present a risk to people, property or the environment. The occurrence of an accident involving these vehicles creates a problem in terms of impact (pollution, toxicity...) and also at the induced crisis management (safety measures, evacuation decision...).

This agglomeration, characterized by a defective road condition, adverse weather conditions (strong rain, fog) can make impossible the use of roads.

The current study aims to analyze the risk of accidents especially for tank trucks carrying hazardous materials in Oran agglomeration and to define an explicit mapping of dangerous roads.

This paper aims to rethink the work presented by the authors in [3], by the proposal of a WEB decision support system (DSS) for identifying and choosing a safe road for the road transport of hazardous materials. This system is conceived according to criteria identified and evaluated in the field by experts in the study domain. Our contribution aims to propose a web application containing a Multecriteria Decision Support System to ensure accurate results by allowing the transporters to consult the system from their starting points. Thus, we can avoid changes that may affect the criteria in function of the time.

After presenting some elements of reflection to introduce the context of our study and the problems associated with risk management, our contribution through the current study is presented in Section 2. The main works related to Hazardous Materials Road Transport (HMRT) are listed in Section 3. Section 4 describes, in its whole, the proposed system named SafeRoad and Section 5 presents, in detail, the decisional process adopted by the proposed Web DSS Safe Road. The relevance of the integration of multicriteria analysis methods in the proposed system are discussed in Section 6. In Section 7, the modeling of Safe Road according to several UML diagrams is detailed. A case study and experimental results are shown in section 8. The last section, summarizes the obtained results and sketch directions of future research.

2. Contribution

To enable a healthy transport, companies are, regularly, faced to decision making. The current study consists to put in place a Web-SDSS in order to facilitate the system access and to allow, therefore, carriers to consult a Decision Support System from their sites for decision-making purposes.

We aim, through this study, the design and development of an interactive multicriteria decision support system “SafeRoad” to identify the least risky paths according to a set of criteria. SafeRoad is available through the web and intended for the TMD allowing carriers to exploit the proposed system from their departure points.

The proposed system "SafeRoad" exploits, simultaneously, web technologies, Geographic Information Systems and Multicriteria analysis methods for decision support. The main features of "SafeRoad" are:

• The invocation of multicriteria analysis methods for decision support via the web.

• The visual and Ergonomic display of the least risky paths through indications and legends dedicated to hazardous materials carriers.

3. Related Works

As indicated and listed in the work of [19] the determination of optimal Roads for trucks carrying hazmat has received significant attention in the literature mainly [1, 6, 11, 21].

Others studies cited in [7] deal with the evaluation of hazardous materials transportation risk [9, 10, 20] where a site-oriented risk analysis is made and tested in pilot areas. Road designing approaches integrating the geographic information systems (GISs) [16] and multi-criteria-based analysis of sustainable development of transportation zones [26, 18, 17] influence the safety of transportation in extremely engaging regions and junctions (nodes) of transport networks.

In the same vein as the recent works such as those of [19] or [26], and in order to give proper guidance to decision makers in identifying different dangerous roads.

The DSS proposed in [3] , explicitly, addresses the importance of road traffic monitoring considering variability and dynamics. The main objective was to propose a spatial multi-criteria DSS using simultaneously a GIS coupled to a variety of multicriteria analysis methods (ELECTRE III, PROMETHEE I,PROMETHEE II) [24]. The results obtained by the multi-criteria approach, was analysed in a second step with an approach based on the hazard science1.

4. The Proposed System « SafeRoad»

The decision support tool that we developed, in the current study provides decision makers (Truckers) a web access to a multicriteria Spatial DSS named SafeRoad. The latter allows them to decide which roads take in order to avoid risks in the transportation of hazardous materials.

In this optic, we propose a web client_serveur system offering three main interfaces namely: a client interface, an administrator interface and a super administrator interface in addition to a territory model.

4.1 Client Interface

This interface provides carriers a user guide (PDF format), they will find the application operation mode and a page explaining the rules of hazardous materials transportation.

4.2 Administrator Interface

This interface provides the administrator the ability to manage truckers accounts. Truckers must launch the decision support system and choose which multicriteria analysis to be use.

4.3 Super Administrator Interface

The super administrator is a privileged administrator; this interface provides it the opportunity to manage administrator accounts in addition to truckers accounts.

In addition, the proposed system exploits a Geographic Information System (GIS) that facilitates the processing of spatial information according to road networks.

For this purpose, multi-criteria analysis is performed to assist carriers for choosing the least risky roads, this is done using a multi-criteria analysis engine exploiting two multicriteria methods namely ELECTRE I and PROMETHEE II.

4.4 Territory Model

This model provides a spatial representation of the studied system. We consider and use only the generic functionalities common to all GIS, without making any additions or changes. Being, intrinsically, tools for managing geographic information, GIS will allow, principally, the management of geographical knowledge. Thanks to its features, it is possible to:

• Manage the geographic database and allow archiving spatial information;

• Handle and examine geographic databases;

• Provide a spatial representation of the studied systems;

• Format and visualize data.

We exploit GIS capabilities to prepare the necessary inputs for decision-making. When decision makers identify the actions (the roads) and the criteria, a value (performance) is assigned to each action according to each criterion using the analytical capabilities of GIS [14].

All the actions and their notes on various criteria constitute the matrix of performances (Table of evaluation) managed by the GIS. The matrix of performances is saved in a database accessible by the admin interface. A second database is used to save the results of multicriteria analysis (choice, ranking…) realized by the admin interface and the graphical displaying (maps, geographical information,…) done by the client interface.

The following figure (Figure 1) shows the overall architecture of the proposed Web DSS SafeRoad:

Figure 1. The overall architecture of the proposed Web DSS SafeRoad

5. The Decision-Making Process Adopted by SafeRoad

The decision-making process adopted by SafeRoad and corresponding to the functional architecture of the developed web decision support system is illustrated in the (Figure 2). Indeed, while collecting criteria the admin and client agents are launched.

• The first (admin) collects the actions and the second (client) sends the points of departure and arrival. These three tasks allow preparing the matrix of performance and, as a result, the multicriteria analysis.

• Once this last task finished, the system provides to the user:

• A set of the less risky roads by resolving a choice problematic using the multicriteria analysis method ELECTRE I

• Or a list of classified roads form the best to the less good using the multicriteria analysis method PROMETHEE II.

• Thus, these results are displaying on a graphic chart using the system interfaces.

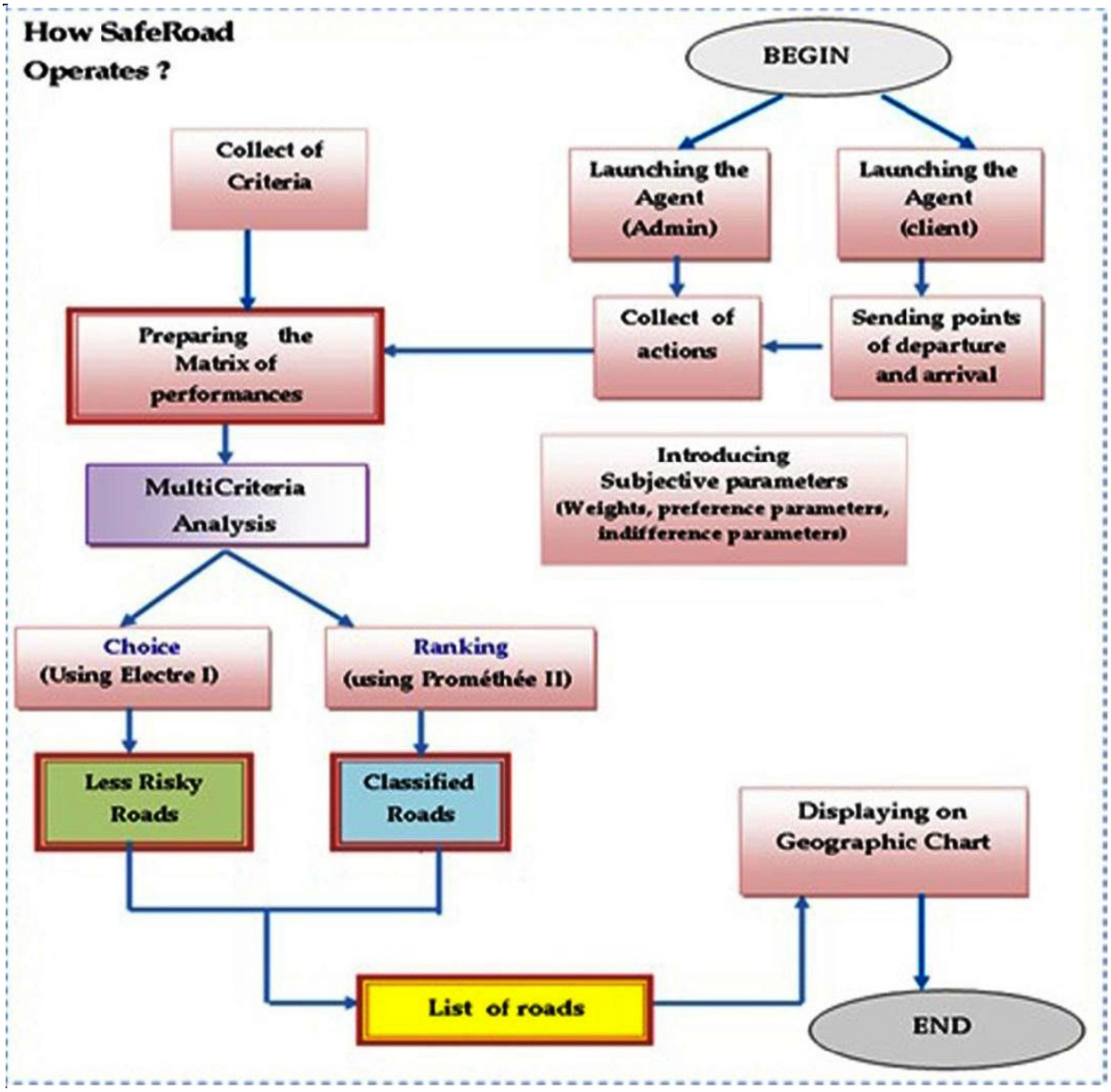

Figure 2. The decision-making process adopted by SafeRoad

6. Relevance of Multicriteria Methods in SafeRoad

Multicriteria analysis methods are based on constructive approaches that encourage dialogue between different actors in the decision process. They are relevant when facing decision situations with the following characteristics [14]:

• The decision-maker (DM) wants to include in the model at least three criteria. However, aggregation procedures are more adapted in situations when decision models include more than five criteria (up to twelve or thirteen).

• Actions are evaluated (for at least one criterion) on an ordinal scale or on a weekly interval scale. These scales are not suitable for the comparison of differences.

• A strong heterogeneity related with the nature of evaluations exists among the criteria (example: duration, noise, distance, security, cultural sites, monuments,).This makes it difficult to aggregate all the criteria in a unique and common scale.

• Compensation of the loss on a given criterion by a gain on another one may not be acceptable for DM. Therefore, such situations require the use of non-compensatory aggregation procedures.

• For one criterion, at least, the following holds true: small differences of evaluations are not significant in terms of preferences, while the accumulation of several small differences may become significant. This requires the introduction of discrimination thresholds (indifference and preference).

In the current study, we opt for the mix use of ELECTRE and PROMETHEE methods namely (ELECTRE I and PROMETHEE II) in the proposed decisional model in order to:

• Satisfy the characteristics previously cited;

• Remain the closest methods to the human reasoning, and that by integrating the parameter "Pseudo criterion" based on "fuzzy logic".

• Exploiting the partial aggregation approach adopted by ELECTRE and PROMETHEE. This approach allow representing the hesitations of the decision maker by comparing the actions by pair then aggregation of the obtained partial preferences.

6.1 Why ELECTRE I

The choice of using ELECTRE I is justified by the simplicity of its principle. Indeed, it is the only multicriteria method to solve a problem of choice.

6.2 Why PROMETHEE

Many methods have been developed for solving multiple criteria ranking problems mainly ELECTRE III [23, 24] (developed by B.Roy in 1977), AHP [25] (developed by Saaty in 1980), PROMETHEE I, II [4, 5] (developed by Brans, Vincke and Mareschal in1984) and SMART [8] (developed by Edwards in 1971).

Each of the methods is constructed around different methodological principles. For example, the ELECTRE III method of the European inspiration is based on the outranking relation, while the Analytic Hierarchy Process (AHP) method of the American inspiration is based on the multiattribute utility theory. Methods based on the total aggregation have the advantage of being simple for use, but reduce complex problems to a single scale, which is often an oversimplification.

These methods often lead to a too conservative representation of the problem. Methods of classification based on the outranking relation offer greater flexibility by introducing semi quantitative scales.

Many factors influenced the specific selection of the multicriteria method PROMETHEE II to solve the ranking problem in our context. Indeed, the use of this method in ranking and classification problems, present the following advantages [2, 5, 12, 15].

• Mix Potential use of both quantitative and / or qualitative criteria;

• Acceptance and integration of the concept of incomparability of alternatives (useful in the case of scenarios too different to be compared), in the whole procedure of classification or ranking;

• Treatment of non-comparability, with two approximations, so as to focus on the alternatives that exhibit special characteristics;

• Simplicity of comparisons and consequentially understanding of the results;

• Exploitation of the subjective parameters (weight, indifference and preference thresholds) attributing a high level of effectivity to the decision support process.

6.3 The Principle of the Multicriteria Method ELECTRE I

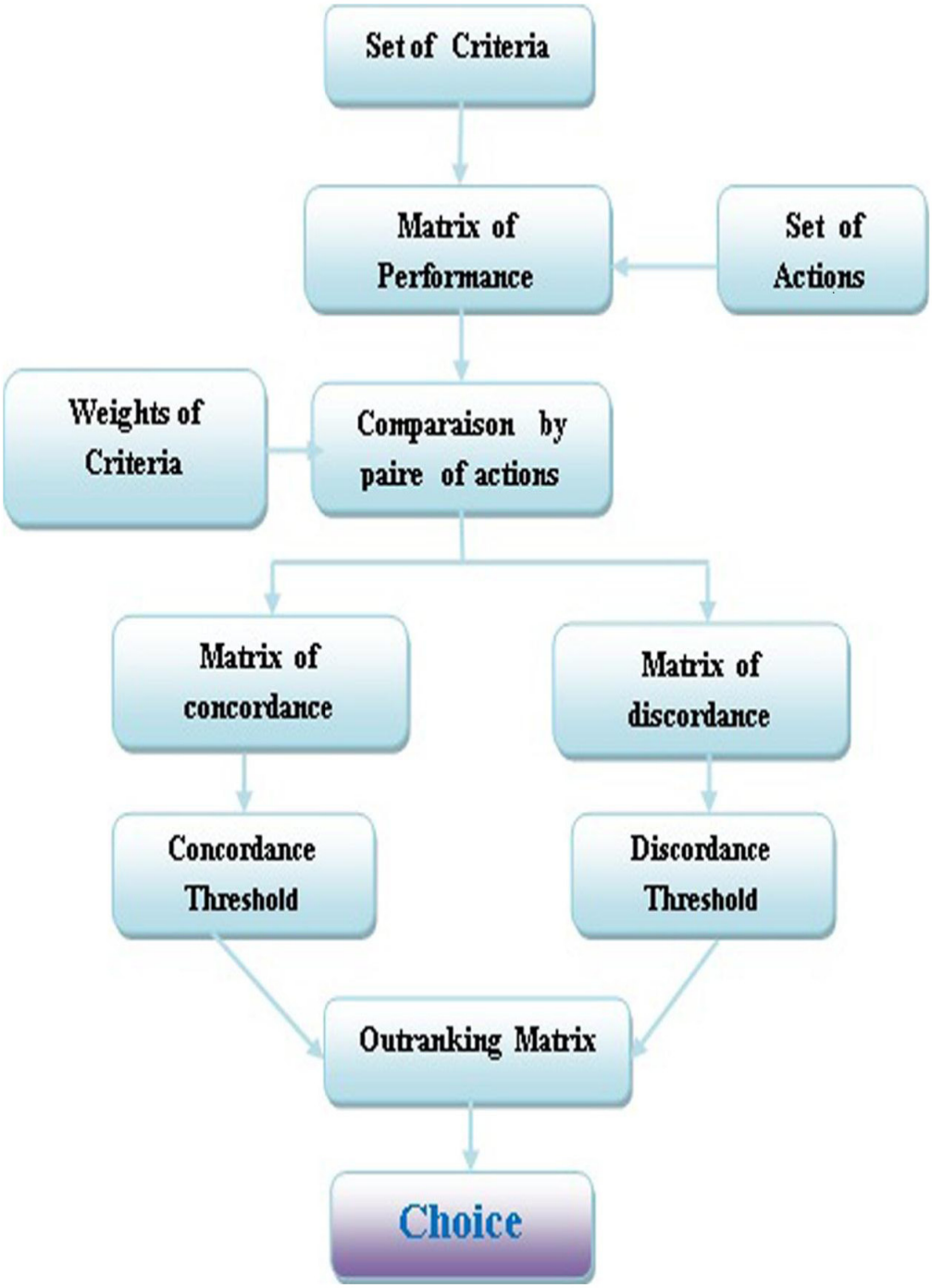

Figure 3. General approach of ELECTRE I

6.4 The Principle of the Multicriteria Method PROMETHEE II

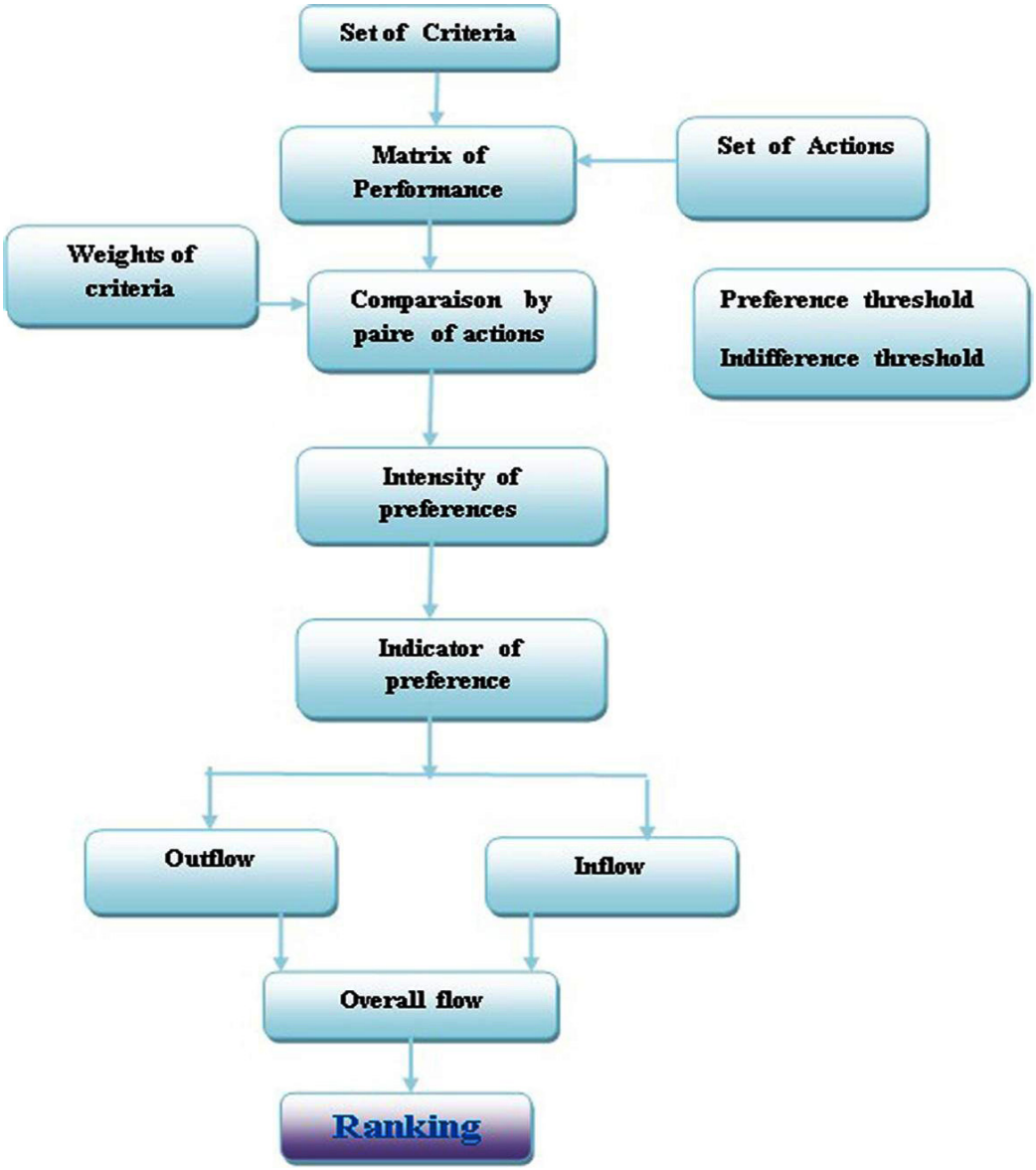

Figure 4. General approach of PROMETHEE II

7. UML Modeling of SafeRoad

To model SafeRoad, we opted for the UML model that allows, at the same time, a simplified and schematic view of our application. We present in the following sections the various associated UML diagrams.

7.1 UML Use Cases Diagram

The UML use case diagram is a reflection on the expected features of the future system before conception; it secures an idea about the main modules of the system and illustrates nb the features that must be provided by each component.

These features will help users to perform their tasks. In the context of our application, we identify five use cases illustrated in Figure 5:

• **Use case 1:** To authenticate: (login trucker, login Admin, login Super Admin);

• **Use case 2:** Provide the least risky paths (trucker);

• **Use case 3:** Analyze paths (Admin);

• **Use case 4:** Manage users (Super Admin);

• **Use case 5:** Manage truckers (Admin).

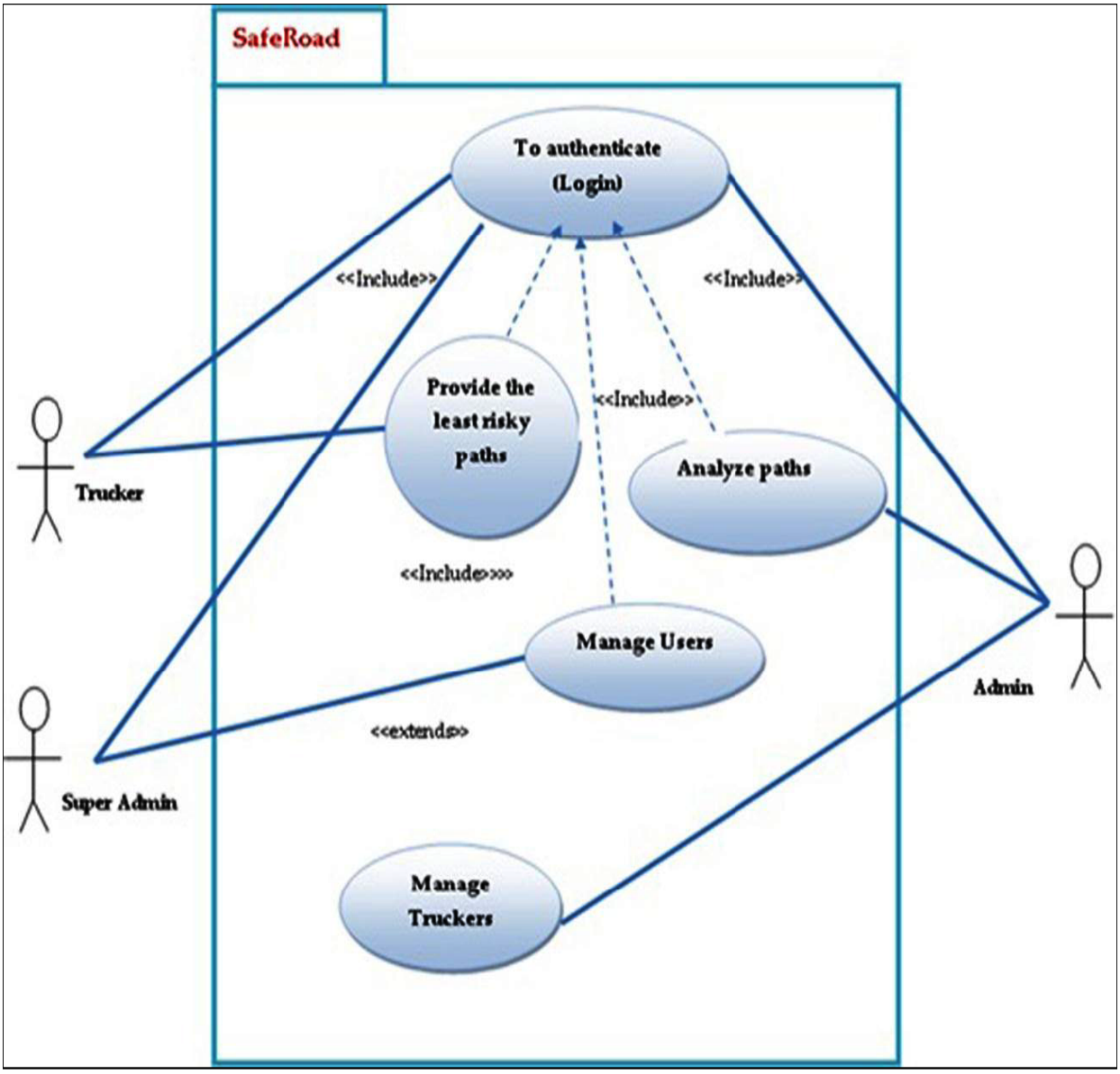

Figure 5. UML Use Cases Diagram

7.2 UML Class Diagram

A class diagram is a collection of static modeling elements (classes, packages, etc.) , il shows the structure of a data model. A class diagram ignores dynamic and temporal aspects.

The UML Class diagram associated to SafeRoad consists of 07 classes illustrated in Figure 6 and discussed below:

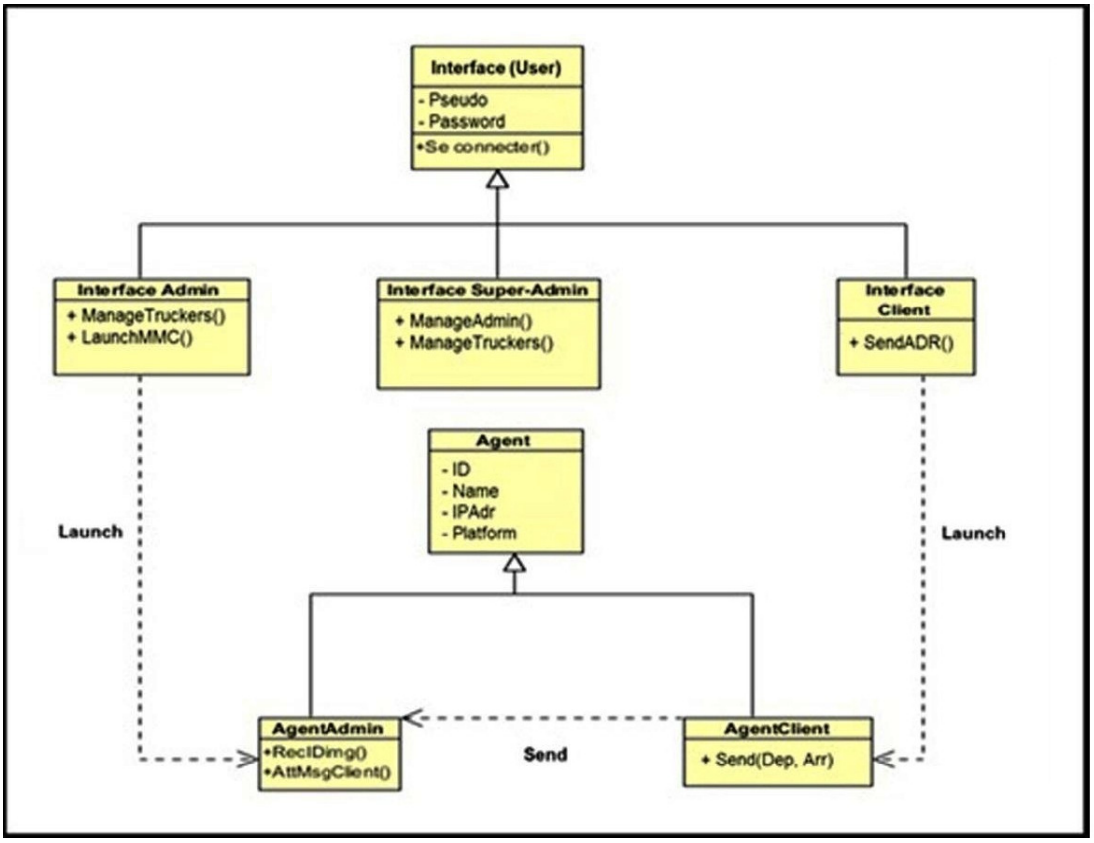

Figure 6. UML Class diagram corresponding to SafeRoad

Class 1: Interface (User)
This class corresponds to the interface that provides the system to the different users, it allows them to connect through a username and a password. This class has three subclasses namely Admin Interface, Client Interface and SuperAdmin Interface:

Class 2: Interface (Super-Admin)
This class represents the management interface of user accounts.

Class 3: Interface (Client)
It has the method EnvoiADR () that allows it to send to the Admin interface its point of departure and arrival by launching the class AgentClient.

Class 4: Interface Admin
Has two methods labeled in order Manage truckers () and Launch MMC(), this class launches Agent Client class.

Class 5: Agent
Represents an intelligent agent and has the following attributes: Id, Name, AdrIP, Platform.

Class 6: AgentClient
Inherits from the Agent class that represents an intelligent agent and has the methods Send Adr() and Send (Dep,Arr)

Class 7: AgentAdmin
Inheriting from the Agent class and the AgentClient class, it possess the methods Recover IdImg() and Wait MsgClient().

The following table describes all the used methods.

Method	Signification
Sign in ()	Belongs to the user class and provides access to the system.
Manage truckers()	Belongs to the classes interface-Admin and interface SuperAdmin. It allows truckers management.
Manage admin()	Belongs to the class and interface SuperAdmin and permits managing all the administrators.
Launch MMC()	Belongs to the admin class and permits launching the multi-criteria analysis.
Send A dr()	Belongs to the client interface class and permits sending the path that wants to travel the trucker.
Send (Dep, Arr)	Belongs to the class agentClient and permits sending the points of departure and arrival of the trucker.
Recover Idlmg()	Belongs to the agentAdmin and permits the recovering of the path identifiant.
Wait MsgClient()	Belongs to the agentAdmin and keeps you waiting for the client request.

Table 1. Summary of the class diagram methods

7.3 UML Sequences Diagram

Sequence diagrams are used to represent collaborations between objects according to a temporal point of view; it puts emphasis on the chronology of sending messages. The associated UML sequence diagram is shown in figure 7.

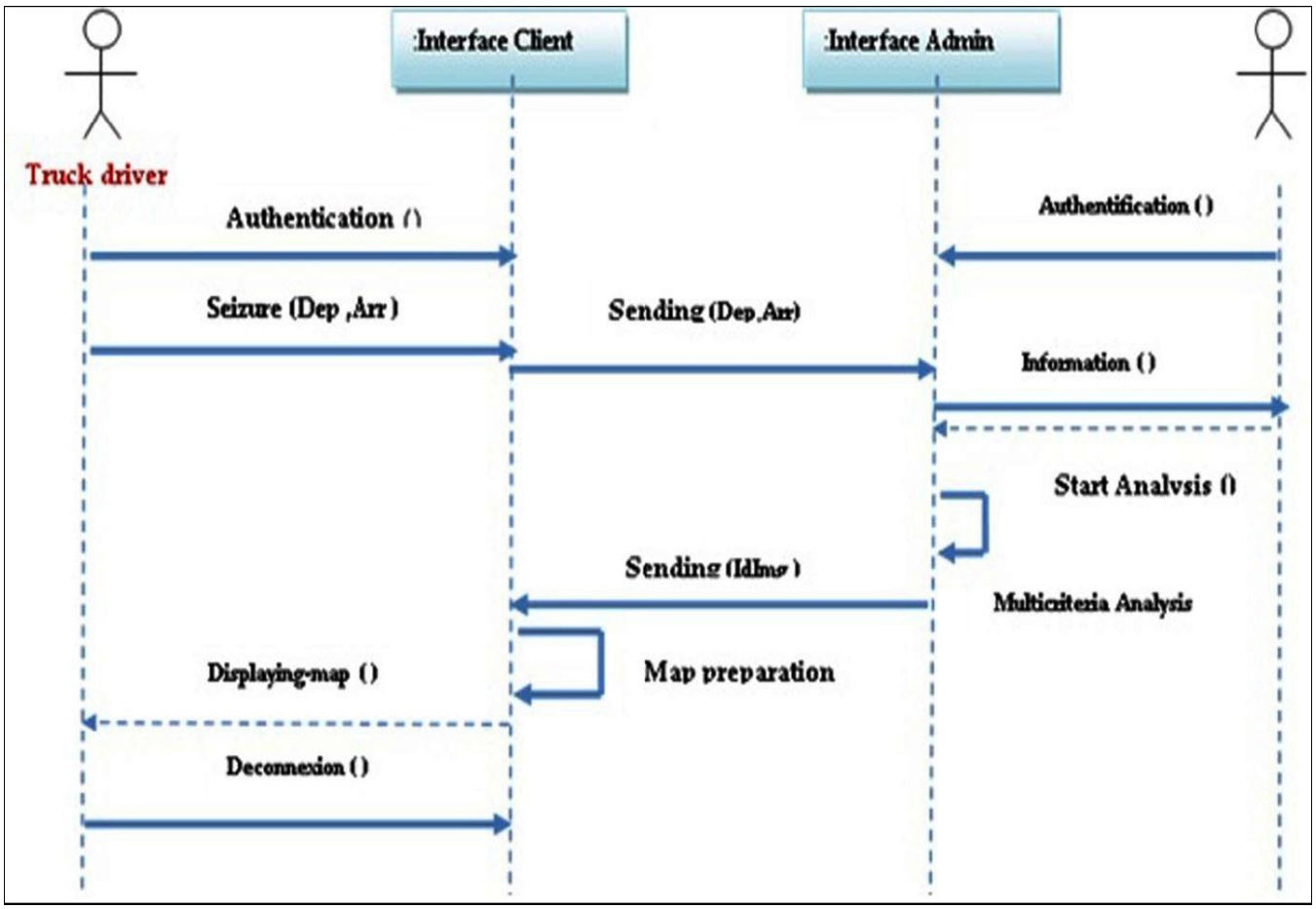

Figure 7. UML sequences diagram

8. Simulation of the Decision Making Process: A Case Study

8.1 The Addressed Problem

The implementation of the proposed web decision support system is accompanied by an application on a test region. The objective of this simulation exercise is to support the proposed methodology by a confrontation with the available tools and data. In addition, testing SafeRoad on an existing region (with real data) allows the validation of our proposal.

We aimed in this case study the conception and the realization of an interactif and multicriteria tool of decision support accessible via the web and intended to the TMD.

The proposed system "SafeRoad" exploits simultaneously the web technologies and the multicriteria methodology of decision support. The principal functionalities of "SafeRoad" are:

• Invocation of the multicriteria methods of decision support via the web.

• Visual and convivial display of the less risky roads via indications and captions at the service of the transporters.

This example deals with the storage of paths leading « société de distribution d électricité et de Gaz d ouest » to « PetroSer cité Djamel » .

8.2 Identification of the Area of Study

In our study, we considered the city of Oran, which is a very productive and populous city, where the transport of hazardous materials is very frequent and can constitute a great risk to the inhabitants of this city involving nearly 04 million of inhabitants not counting tourists, foreign students,...

The used map is taken from Google Maps, we chose an area that contains the stations Petroser well known for their fuel supplies. Descriptions on the map of Oran specify the locations or areas where stations are located. The distribution of the different stations on the appropriate map is illustrated by the following figure:

Figure 8. Distribution of Petroser Stations at Oran

8.3 Formulation of the Multicriteria Decisional Problem

In this study:

• Each action represents a possible path to any station from any one deposit.

• It should be noted that the data processed, in our study, and manipulated by SafeRoad are strictly related to roads according to four basic criteria namely : the surrounding population, **the state of the road, Path Length** and the **Circulation:**

Criterion 1: The surrounding population, measures the surrounding population along the road from the central repository to the gas station.

Criterion 2: The state of the road, describes the state of the road, can take three possible values:

$$\begin{cases} 1\text{: The road is in good condition.} \\ 2\text{: The road is state may deteriorate.} \\ 3\text{: The road is in bad condition.} \end{cases}$$

Criterion 3: Path Length, measures the length of the path from the deposit to station

Criterion 4: The Circulation, describes the intensity of circulaltion in this path, can take three possible values:

$$\begin{cases} 1\text{: The road has a heavy traffic.} \\ 2\text{: The road has an average circulation.} \\ 3\text{: The road has a low circulation.} \end{cases}$$

8.4 Evaluation of Performances

The definition and assessment of the identified criteria according to different actions generate the matrix of performances, illustrated in (Table 2).

The following table shows the matrix of performance associated with paths leading from the "station Petroser tarik Ben ziyad " to the " the west gas and electricity distribution company" . This matrix is an essential input for the execution of each multi-criteria method.

	Crt1	**Crt2**	**Crt3**	**Crt4**
Path1	17758	1	0.00806	2
Path2	37315	2	0.00804	3
Path3	11579	2	0.01777	3
Path4	17758	2	0.01126	2
Path5	609014	1	0.00095	3

Table 2. Matrix of performances

8.5 Definition of Subjective Parameters

To be conducted, the multicriteria methods ELECTRE I and PROMETHEE II introduce some subjective parameters. In the following, we show how SafeRoad assigns values to these parameters [13].

• **Weight:** Is a number ω_j, $\{j = 1, 2,...m\}$ (m designate the number of criteria) assigned to each criterion, according to its importance regarding other criteria. This is not always easy for the decision maker, to articulate his assessment of the relative importance of each criterion. To assign a value to this intra criteria parameter, we used the Saaty scale. The latter allows evaluating various criteria and ordering them according to their relative importance. The scale of Saaty is based on a mathematical model developed

by Thomas Saaty [32]. After comparing sequential pairs of criteria (each criterion is assessed on all the others in a series of comparisons).

We ask the user to order on a scale from (-9 to 9) the relative importance of one criterion over another.

• **Thresholds:** In our study, thresholds of preference and indifference p_j and q_j on the criteria j, respectively, are chosen based on values assigned to data uncertainties. For example for an uncertainty of 20:

$$p_j = 0{,}4 * max_{(i,\,k)}\,[g_j(a_k) - g_j(a_j)]$$

$$q_j = 0{,}2 * max_{(i,\,k)}\,[g_j(a_k) - g_j(a_j)]$$

Where

$g_j(a_i)$: The performance of the action *ai* according to criterion j.

$g_j(a_k)$: The performance of the action *ak* according to criterion j.

The values of subjective parameters expressed the decision maker are given by the following table (Table 3):

	Crt1	**Crt2**	**Crt3**	**Crt4**
Indifference thershold	1	1	0.25	0.5
Preference thershold	3	2	0.75	1.5
Weight	0.5	1.5	2	0.2

Table 3. Subjective parameters expressed by the decision maker

8.6 Unfolding of the Simulation Process
Specifying Path (Client Interface)

Figure 9. Home interface of SafeRoad

Once the application is launched, the user will face an interface (Figure 9) allowing him:

• To connect, he will fill the login information to access features of SafeRoad;

• To access the page explaining the rules of TMD

Once connected, the client must choose his points of departure and arrival from two dropdown lists. The Figure 9 illustrates this step.

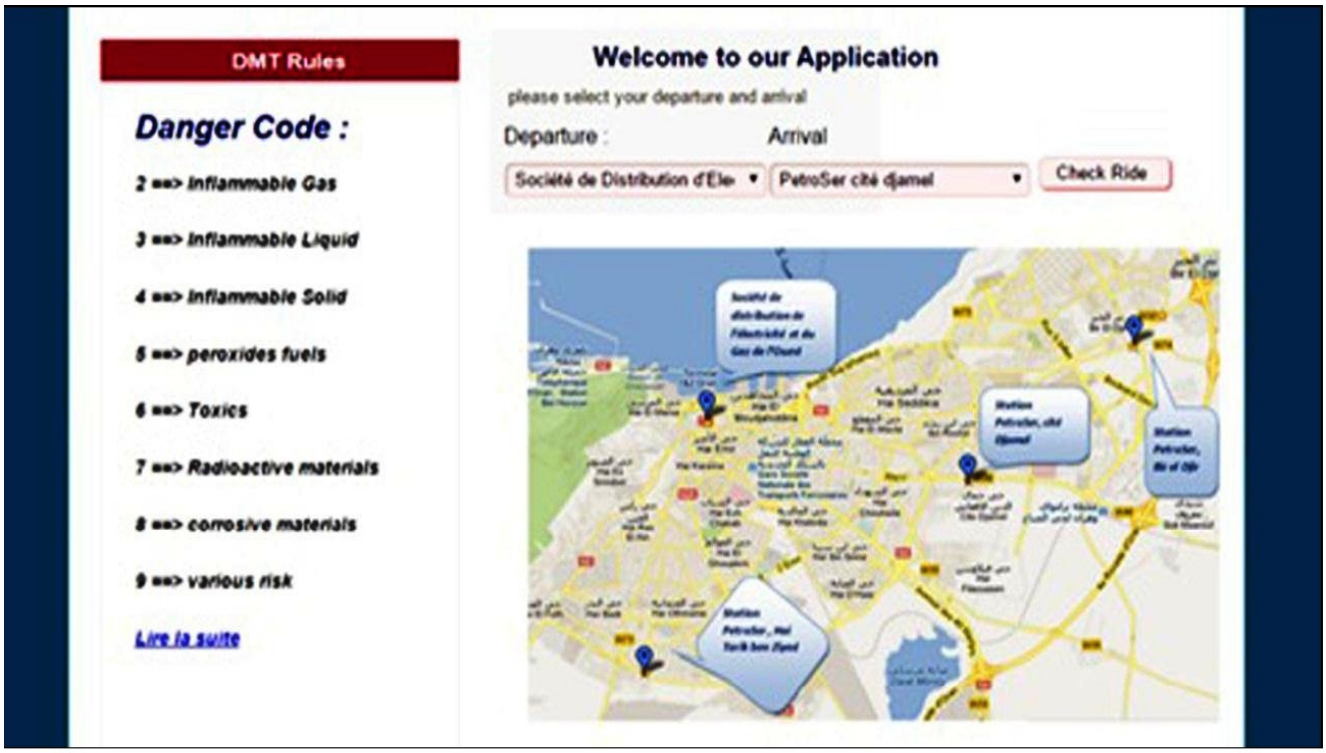

Figure 10. Interface mailing address of departure and arrival

Figure 11. Adding a trucker (admin)

Managing user Accounts (Interface Admin)
Once connected, the administrator will be able to launch a multicriteria analysis –method (ELECTRE I or PROMETHEE II°) and manage trucker accounts as shown in the following figure.

To add a trucker, the administrator must fill in a form by entering his username and his password (Figure 11). For this purpose, the administrator may, at any time, consult the registered truckers list and delete one or more truckers (Figure 12).

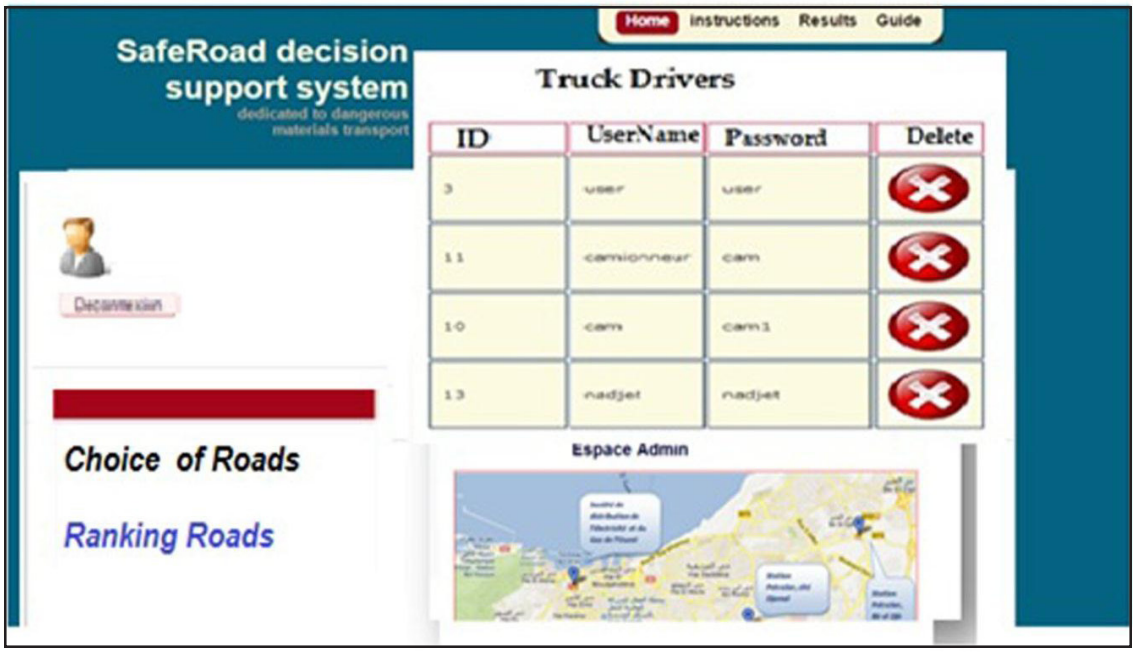

Figure 12. Displaying the trackers

Ranking Paths Interface
This interface (Figure 13) allows the administrator to run the multicriteria analysis –method PROMETHEE II and have the storage of actions according to the identified criteria.

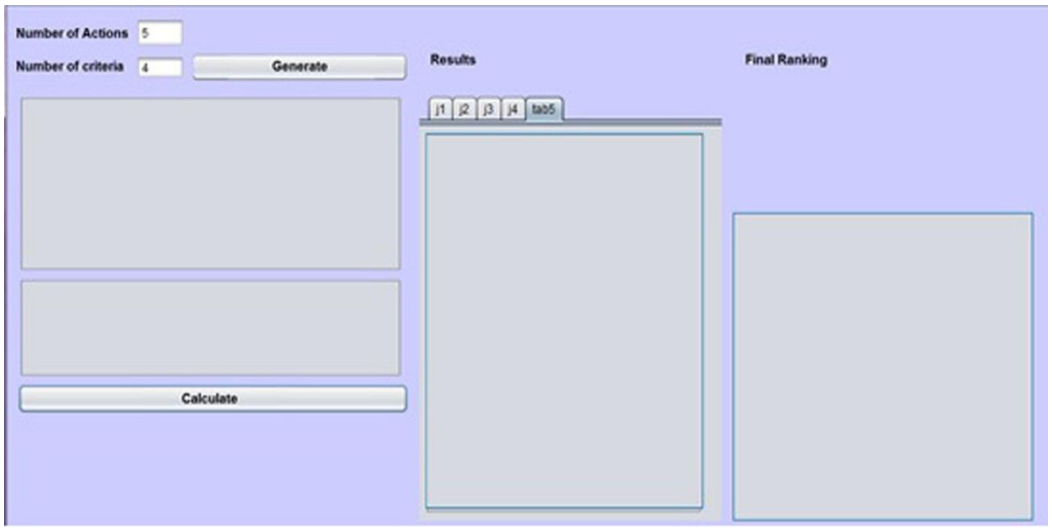

Figure 13. Ranking path interface

This example shows the ranking of the storage paths leading to “company for electricity distribution and West Gas” to “Petroser Djamel city.” The client sends its point of departure and arrival through the following form:

Figure 14. Sending departure and arrival points formulary

The administrator starts the storage method PROMETHEE II as follows:

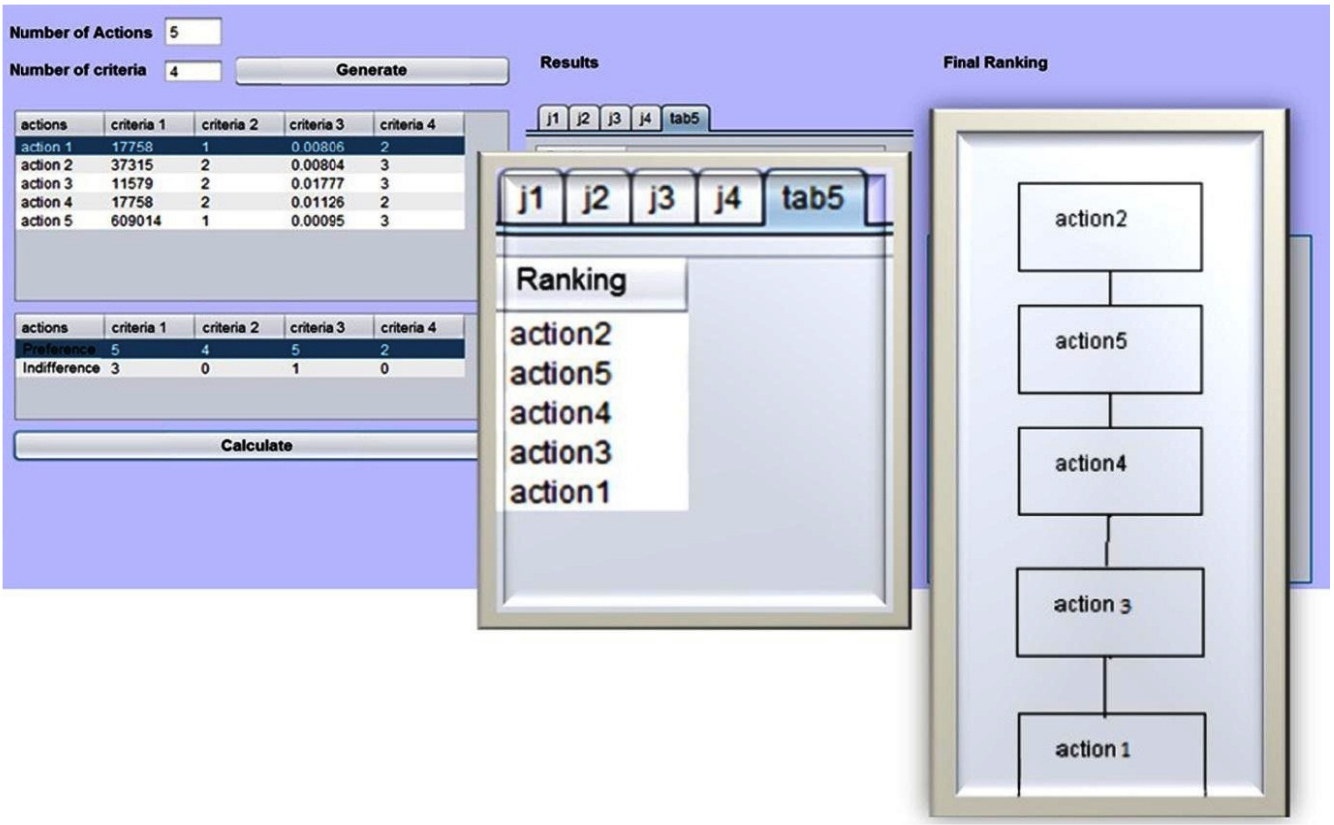

Figure 15. Results provided by PROMETHEE II

At the Server Level

The multi-criteria analysis engine provides a list of stored paths and a graph display upgrade method. Once processing is complete, the administrator will validate the result by clicking on the “ validate” button.

At the Client Level

At the Client Level: The map will be displayed with the stored paths, different ranks are specified with different colors and

captions while indicating the degree of danger of itinerary in question on the map as shown in the following figure.

Figure 16. Paths stored on the card of Oran

The result is displayed in 5 colors expressing degrees of danger, the paths are ranked from less risky to more dangerous.

9. Conclusion

In this article, we discussed the hazardous materials transportation problems in town that is part of major technological risks. This type of transport exposes people to pollution, explosions and fires which impacts can be catastrophic.

The main objective of the current study is to provide a mapping service dedicated to HMRT through a web interface containing an interactive Multicriteria Spatial Decision Support System using GIS and Multicriteria methods namely ELECTREI and PROMETHEE II. This allows carriers to operate the system from their sites.

We think that it would be interesting to develop this study by:

• Integrating a dynamic mapping tool in order to ensure the dynamic aspect to the system.

• Improving the prototype by introducing management upstream and downstream of transport of hazardous materials in the city.

• Exploiting other multicriteria methods (partial aggregation and total aggregation).

• Exploiting of the GIS spatial analysis functions to generate precisely the performance matrix.

References

[1] Akgun, V., Parekh, A., Batta, R., Rump, C. (2007). Routing of a hazmat track in the presence of weather systems, *Computers and Operations Research*, 34 (5)1351–1373.

[2] Azzabi, Ayadi., D. (2010). Optimisation Multicritere De La Fiabilite: Application Du Modele De Goal Programming Avec LesFonctions De Satisfactions Dans L industrie De Traitement De Gaz. *PHD Thesis*, University of Sfax, Tunisia.

[3] Bouamrane, K., Hamdadou, D., Yachba, Kh., Guenachi, Kh. (2012). Towards a decision support system, application: Itineraryroad modification for road transport of hazardous materials, *International Journal of Decision Sciences, Risk and Management*, 4 (3/4).

[4] Brans, J. P., Vincke, P. H., Mareschal, B. (1986). How to select and how to rank projects: the PROMETHEE methods. *EuropeanJournal of Operational Research*.

[5] Brans, J. P., Mareschal, B. (2001). Prométhée - Gaia : Une méthodologie d aide à la décision en présence de critères multiples.*Series: "Statistique et mathématiques appliquées"*, Editions of university de Brussels, *Belgium*, p 192.

[6] Chang, T-S., Nozick, L., Turnquist, M. (2005). Multiobjective path finding in stochastic dynamic networks, with applicationto routing hazardous materials shipments, *Transportation Science*, 39 (3)383–399.

[7] Dzemydiene, D., Dzindzalieta, R. (2010). Development of architecture of embedded decision support systems for riskevaluation of transportation of dangerous goods, *Technological and Economic Development of Economy*, 16 (4)654–671.

[8] Edwards, W. (1971). Social utilities. Engineering Economist, 6th Series of Summer Symposium, p 119-129.

[9] Fabiano, B., Palazzi, E., Curro, F., Pastorino, R. (2001). Risk assessment and decision-making strategies in dangerous goodtransport. From an Italian case-study to a general framework', Loss Prevention and Safety Promotion in the Process Industries. Proceedings 2, *Elsevier Science* B.V. Amsterdam, NL, p. 955–966.

[10] Fabiano, B., Curro, F., Reverberi, A. P., Pastorino, R. (2005). Dangerous good transportation by road: from risk analysis toemergency planning, *Journal of Loss Prevention in the Process Industries*, 18 (4–6) 403–413.

[11] Haghani, A., Chen, Y-J. (2003). Routing and scheduling for hazardous material shipments on networks with time dependenttravel times, *In*: Paper presented at the 82nd Transportation Research Board Meeting, Washington, DC.

[12] Halouani, N., Chabchoub, H., Martel, J. M. (2009). PROMETHEE-MD-2T method for project selection. *European Journal of Operational Research*. 195, p 841-849.

[13] Hamdadou, D., Libourel, T. (2011). A MultiCriteria Group Decision Support System for Industrial Diagnosis *INFOCOMPJournal of Computer Science*, Lavras, MG, Brazil, 10 (3) 20-55.

[14] Hamdadou, D., Bouamrane, K. (2016). A Spatial Group Decision Support System: Coupling Negotiation and MulticriteriaApproaches, *Intelligent Decision Technologies* 10 (2) 129-147.

[15] Hammami, A. (2003). Modélisation technico-économique d une chaine logistique dans une entreprise réseau. *PHD thesis*.Superior National School of Mines of Saint- Etienne.

[16] Jakimaviius, M., Burinskien, M. (2009). A GIS and multi-criteria-based analysis and ranking of transportation zones ofVilnius city, *Technological and Economic Development of Economy*, 15 (1)39–48.

[17] Kaklauskas, A., Zavadskas, E. K., Saparauskas, J. (2009). Conceptual modelling of sustainable Vilnius development,*Technological and Economic Development of Economy*, 15 (1)154–177.

[18] Kavaliauskas, P. (2008). 'A concept of sustainable development for regional land use planning: Lithuanian experience',

Technological and Economic Development of Economy, 14 (1)51–63.

[19] Kim, M., Miller-Hooks, E., Nair, R. (2011). A geographic information system-based real-time, Decision support frameworkfor routing vehicles carrying hazardous materials, *Journal of Intelligent Transportation Systems*, 15 (1)28–41.

[20] Milazzo, M. F., Lisi, R., Maschio, G., Antonioni, G., Sadoni, G. (2010). A study of land transport of dangerous substances in Eastern Sicily, *Journal of Loss Prevention in the Process Industries*, 23 (3)393–403.

[21] Miller-Hooks, E., Mahmassani, H. (1998). Optimal routing of hazardous materials in stochastic, time-varying transportationnetworks, *Transportation Research Record*, 1645, p.143–151.

[22] Palanisamy, S., Sebastien, J., Vankantesen, S. (2015). Safety Analysis chemicals transportation by Indian roads, Academic Journals, *Scientific Research and Essays* 10 (2)53-57.

[23] Roy, B. (1985). Méthodologie multicritère d aide à la decision. *Journal Economica*, Paris.

[24] Roy, B., Bouyssou, D. (1993). Aide multicritère à la décision : méthodes et cas, Economica. B. Roy et D. Boyssou, « Aidemulticritère à la décision : Méthodes et cas », Economica, Paris.

[25] Saaty, T. L (1980). The Analytic Hierarchy Process, Planning, Piority Setting, Resource Allocation. McGraw-Hill, New York.

[26] Zavadskas, E. K., Kaklauskas, A., Kaklauskien, J. (2007). Modelling and forecasting of a rational and sustainable developmentof Vilnius, emphasis on pollution, *International Journal of Environment and Pollution*, 30 (3–4)485–500.

Author Biographies

Djamila HAMDADOU received her Engineering degree in Computer Science and her Master of Science degree from the Computer Science Institute (University of Oran, Algeria) in 1993 and 2000, respectively. She also obtained her doctorate in 2008. She received her PhD in 2012 from the Computer Science Department. Her research interests include Decision support systems, Multicriteria Analysis, Multi agents systems, Geographic Information Systems and Decision Information Systems.

Emdjed ALNAFIE received his Engineering degree in Computer Science in 2008 and his Master of Science degree in 2011 and his PhD in 2016 from the Department of Computer Science, (University of Oran, Algeria). His research interests include Multicriteria Analysis, Interoperability of Geographical Information Systems, Ontologies and Multi-Agent Systems.

Karim Bouamrane received his Engineering degree in Computer Science and his Master of Science degree from the Computer Science Institute (University of Oran, Algeria) in 1991 and 1996, respectively. He also received his PhD in 2006 from the Computer Science Department, University of Oran Algeria. His research interests include decision support system in transport and risk, artificial intelligence, distributed database, and automated production systems.