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Evaluation of an Information Assistance System Based on an Agent-based Architecture in Transportation Domain: First Results

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Abstract:
The evaluation of interactive systems is a wide and rich research domain: many methods, criteria and tools are available. In this article, we are focused on agent-based interactive systems. We first describe the agent oriented architecture used in our researches. Then we propose an evaluation approach based on three complementary techniques: assistance evaluation tool, questionnaire, and verbalization. The validation of our approach occurred within the framework of a project involving an industrial partner which is running the current urban transport network (tramway and bus) in the town of Valenciennes, France. The main results of the evaluation of an agent-based Information Assistance System (IAS) are presented. This evaluation is based on two scenarios: normal or distrupted running mode. This evaluation has been conducted in laboratory.
Keywords: Evaluation, Human-Computer Interaction, Electronic informer, Information Assistance System, traffic regulation.

1 Introduction

The evaluation of interactive system consists in ensuring that the users are able to carry out their task by using the system; it must therefore meet their needs. The methods and tools currently available for evaluating interactive systems are numerous and various; we quote for instance: observations, eye tracking, interviews, electronic informers, questionnaires, user tests, inspection methods, knowledge based automated systems, and so on [14], [19], [16], [20]). Each of them presents some advantages and drawbacks.
In this article we are particularly interested in the evaluation of agent-based interactive systems. Indeed agent-based architectures of interactive systems have been proposed since the eighties in the literature. Such architectures lead to new needs concerning the evaluation of the interactive systems concerned [15], [28], [5], [8].
Thus, we propose an evaluation approach based on three complementary techniques: assistance evaluation tool, questionnaire and verbalization. Urban transport networks, and in particular the system which provides information for the passengers (IAS: Information Assistance System [6]), will be used as an example of the application of our approach.
In this article, we will present the main results obtained from the evaluation of the Information Assistance System (IAS). Indeed, the evaluation in the laboratory has initially enabled us to technically test the proposed assistance evaluation system, and secondly to detect a prior representative set of utility and/or usability problems, inherent to the IAS exploitation.

2 Agent oriented architecture for interactive systems

The architectural design of interactive systems is object of many researches since the eighties. Architecture of an interactive system is composed by components, the outside visible properties of these components and the relations between them [4]. In general, the proposed models respect the following principle: the separation of the user interface part from functional core (application) part; as a result, the flexibility, reusability and maintainability are increased. We can distinguish two types of architectural models:

- Functional models, such as the Seeheim and Arch models [1]; functional models split an interactive system into several functional components; for instance, the Seeheim model is made up of three components (Presentation, Dialogue Controller, Application Interface).

- Structural models, such as PAC [3], AMF [2] or MVC [11] (and their variations); the structural models aim at a finer breakdown. Indeed, such models regroup functions together into one autonomous and cooperative entity (often called agent). They are agent-based interactive systems that are built based on a hierarchical structure of agents in accordance with the principle of composition or communication (not on a functional division like functional models). For example, PAC model is a hierarchical structure of interactive agents: a PAC agent is composed by three facets: *Presentation* that connects agents to the input/output devices, *Abstraction* is responsible of functional core of the application, *Control* plays an intermediary role between the two other components and serves communications between PAC agents. Three facets (Model, View and the Controller) also compose an agent of the MVC model.

Each of these models has its own advantages and disadvantages. In order to exploit the advantages of both types of models, we propose an agent-based architectural model that borrows principles of both of them; so this model can be considered as a mixed model. The idea of a mixed model is not new but our proposed agent-based architectural model aims principally at (1) designing complex supervision systems in industrial context, (2) proposing solutions for the evaluation phase, as explained in [25] and [30].
In the architecture used in our researches, we suggest using a division into three functional components (see Figure. 1) which we have called respectively: *interface with the application* (connected to the application), *dialogue controller*, and *presentation* (this component is directly linked to the user). These three components group together agents:

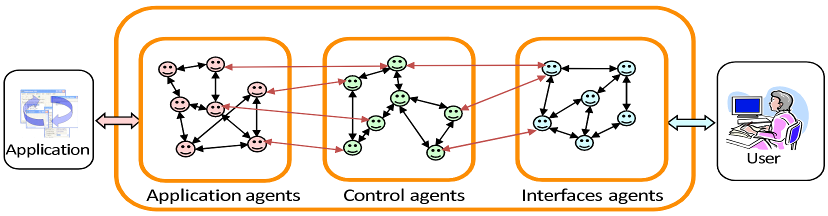

Figure 1: Proposed agent-based architectural model of interactive systems [8]

- The *application* agents handle the field concepts; they cannot be directly accessed by the user. One of their roles is to ensure the correct functioning of the application and the real time dispatch of the information necessary for the other agents to perform their task,

- The *dialogue* control agents are also called mixed agents; these provide services for both the application and the user. They are intended to guarantee coherency in the data exchanges emanating from the application towards the user, and vice versa,

- The *interactive* agents (also called *interface* agents), unlike the application agents, are in direct contact with the user (they can be seen by the user). These agents coordinate between themselves in order to intercept the user commands and to form a presentation which allows the user to gain an overall understanding of the current state of the application. In this way, a window may be considered as being an interactive agent in its own right; its specification describes its presentation and the services it has to perform.

3 Agent oriented specification and design of the information assistance system

Agent oriented architecture has been used for the design of the first version of an Information Assistance System (IAS) [8], [9]. The application agents are intended to manage the passenger information in the vehicles and stations and to calculate the information to be displayed (delays, timetable and route modifications, etc.). Thus we can consider the IAS as a complex system which is a very rich research and development field [10]. According to the traffic context, each agent possesses rules enabling it to act correctly in its environment. Concerning the specification of the *interface* agents, we have identified six types of *interface* agent responsible for direct interaction with the user (human regulator). They are represented in the form of interactive windows. The user can interact with them via the various functions possible in the windows: buttons, edition zones, pictures, and so on. These agents are:

- The *State of the traffic* interface agent: it gives a synthetic representation of all the delays concerning mobile units travelling on the network. Thus, with the help of the network support system, it ensures the real time surveillance of vehicle delays on the network supervised.

- The *State of the line* interface agent: the view of this agent is made up of graphic elements such as stations, route sections, vehicles, and so on (see Figure. 2a). A click on a vehicle directly displays the view (window) of the *Vehicle* agent which will deal with any further interaction with the user (see Figure. 2b). The principle is the same when the user clicks on a station (see Figure. 2c).

- The *Station* and *Vehicle* interface agents: the view of these two agents is accessible by acting on their associated representations in the *State of the line* interface agent view (vehicle and station). It shows the user the information contained in the running plans in the form of a set of thumbnails depending on a direction which can be selected on a drop-down scroll list.

- The *Message* interface agent: it enables the human regulator to obtain a synthetic view of all the messages being sent to vehicles and stations.

- The *Overall View* interface agent: in order to make the task of supervising the traffic easier for the regulator, we created it. As its name implies, the view given by this agent provides the user with a global view of the traffic on the network. This view encompasses all the lines to be supervised and facilitates access to line, stations and vehicles.

A survey of the user interfaces related to these agents is available in [23].

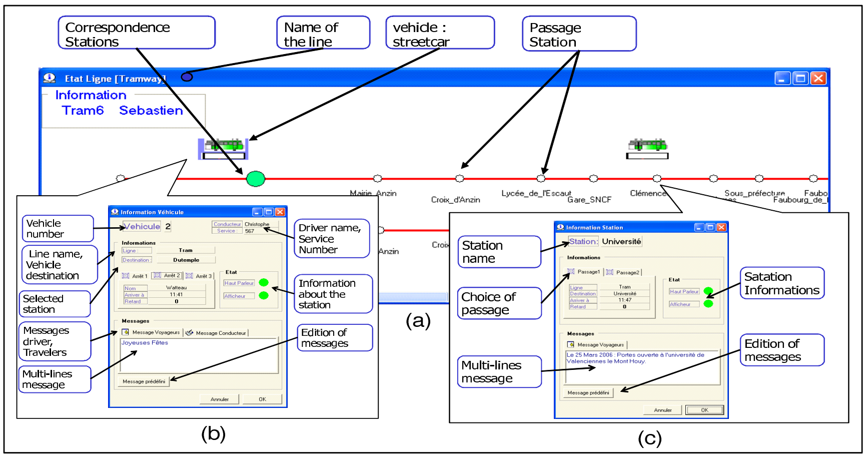

Figure 2: (a) View of the *State of the line* interface agent, (b) the view of a *Vehicle* interface agent,(c) View of a *Station* interface agent [27], [23]

4 Evaluation of the information assistance system (IAS)

4.1 Experimental device

The experimental device of the IAS evaluation consists of three techniques and tools: an evaluation assistance system integrating an electronic informer called MESIA[1] [26], questionnaire and verbalization. The use of each of them is presented hereafter.

Evaluation assistance system

The evaluation assistance system is composed of several modules, shown in the middle of Figure 3 [24], [27].
The *electronic informer* module is directly connected to the interactive system to be evaluated by the association of an informer agent to each agent of the interface. The creation of these informer agents is deduced directly from the architecture of the system which is to be evaluated, more specifically from the presentation agent-based system.
Once the interaction data has been collected and stored, it is used by a module able to generate a task model. This is based on the exploitation of agent Petri nets, inspired by parametrized Petri nets [12], selected for their ability to handle entities of the agent type, according to principles described in [9]: the model obtained corresponds to that of the real activity. This module is also able to generate a model corresponding to the task to be performed, whose components are available in a base intended for this purpose (stored in the BMT(R) base, cf. below). Indeed, two bases are available [22], [27]

- The Base of Specifications of Agents (BSA) allows the storage of the specifications of the *interface* agents. It contains the definition (for each agent) of the sets E (set of the possible events), C (set of the conditions), R (set of the resources), Acv (set of the visible actions: such as the action of the user using the mouse or the keyboard, the reaction of the interface by the posting of new windows and/or change of their contents), Acn (set of the actions which are not visible to the user, relating to the interactions between *interface* agents).

[1] Mouchard électronique dédié à l'Evaluation des Systčmes Interactifs orientés Agents; translated by: Electronic informer dedicated to the Evaluation of Agent-Based Interactive Systems.

The data stored in BSA is intended to be exploited by the module of task model generation (taking the form of agent Petri nets).

- The Base of Task Models (BMT) is composed of two sub-bases called BMT(O) and BMT(R). BMT(O) contains the description of the task observed, the models being generated by the module of generation (of Petri nets). BMT(R) contains the description of the tasks, also called prescribed or reference tasks (to be realized by the users), such as they are described *a priori* by the designers or evaluators via a module allowing Simulation/-Confrontation/Specification of agent Petri nets (cf. below).

The Simulation/Confrontation/Specification module provides the evaluators/designers with the following three functionalities:

- Simulation of agent Petri nets: this function allows the visualization of agent Petri nets dynamics, and in consequence provides an overview concerning the HCI dynamics; this is because of the exploitation of the task models (modelled by agent Petri nets) and of the formulation which ensures the evolution in agent Petri nets.

- Confrontation of agent Petri nets: this function exploits the task models (Observed, of Reference) for confrontation (according to the principles described in [7]). This confrontation aims make it easier for the evaluators to identify possible ergonomic problems related to the usability of the interactive system; for example to realize that agent Petri nets of the task model observed contains states in which, for example, the user passes by useless stages, or where the time taken to carry out a task is far greater than that envisaged *a priori* by the evaluators/designers.

- Specification of agent Petri nets: this function consists of providing the evaluators/designers with means (windows) allowing the management (description, modification, ...) of the agent specification, in other words the definition of the E, C, R, Acv, Acn sets and their storage in the agent specification base (BSA).

More explanation about a specific tool ensuring the generation, the simulation and the confrontation of Petri nets can be found in [30], [29], [28].
In addition to the verbalization, the use of the electronic informer as a tool for the evaluation of the IAS is enriched by subjective answers to a questionnaire.

Questionnaire

The questionnaire prepared specifically for this evaluation is basically inspired from [21]. It is composed of three parts: the first presents questions about the user interface general aspects (such as the response time); the second gathers specific questions about each IAS view (window); and the third part presents a global ergonomic evaluation of the user interface. The complementary technique to the questionnaires is the verbalization.

Verbalization

The verbalization is an easy and direct means to collect information about the quality of the system and particularly the user interface. Contrary to the questionnaire, the verbalization has the advantage of being more flexible insofar as it allows the orientation of the questions towards the information sought by the evaluator [13].

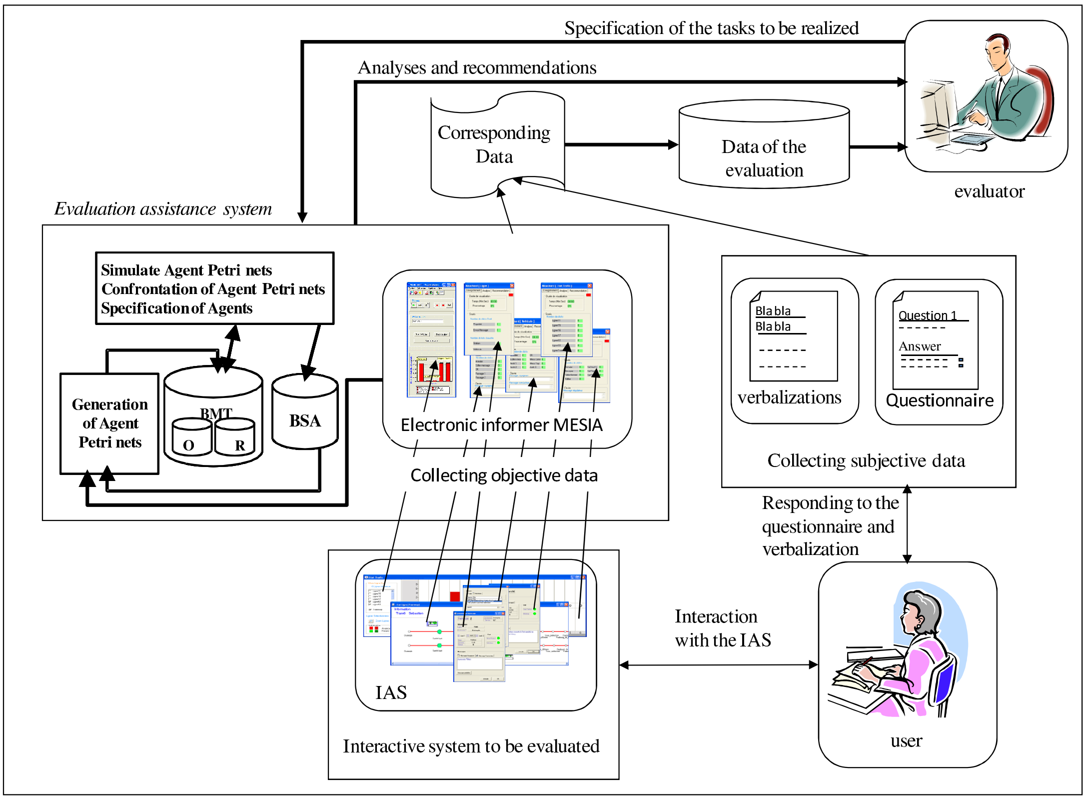

Figure 3: Experimental device used for the IAS evaluation

4.2 Population implied in the evaluation

According to [17], [31], it is possible, with 4 or 5 participants, to detect nearly 80 to 85% of the utilisability problems. Hence, for this first evaluation of the IAS in laboratory, the population is made up of five subjects. They have an average age of 29 years; all are male. All the subjects are PhD students in computer science. We have considered that the fact that the subjects are experts in computer science can compensate, to some extent, their lack of experience in regulation. Indeed, the familiarity of PhD students with the computer software and the human-machine interfaces handling can put them draw sheet with the use of the IAS.
However, it is clear that the results obtained within the framework of this first evaluation will never be as consistent as those which could be obtained with professional human operators in regulation rooms.

4.3 Experimental protocol

Each experiment lasts approximately an hour and half and comprises four phases which are presented in Table 1. During the first phase of the experiment, which lasts fifteen minutes, the IAS and its global functioning are explained to the subject. The subject is then familiarized with the various views of the IAS during approximately ten minutes before undergoing truly the experimental tests. The right handling proceeds in twenty minutes and relates to two scenarios. Ten minutes are devoted to each scenario. The last phase of the evaluation relates to the filling of the questionnaire and the verbalization; it lasts approximately forty-five minutes.

Table 1: Phases of the evaluation

Phase	duration	Task description
1	15 minutes	Reception, description of the evaluation objectives, and global presentation of the Information Assistance System (IAS)
2	10 minutes	Learning and free trial of the IAS
3	20 minutes	Realization (by the user) of two previously prepared scenarios
4	45 minutes	Responses to the questionnaire and verbalization of the user

4.4 Tasks to be realized

Scenario 1: evaluation of the IAS in normal running mode

In the reality, in normal running mode, analyses showed that the task of the human regulators amounts to the supervision of the traffic, but that they can also, of their own initiative, send messages to vehicles and to stations. Within the framework of the evaluation, we thus get closer to this established fact. To make sure that the user (the subject) easily succeeds in interacting with the IAS by sending messages to the station(s) and the vehicle(s), we propose a first evaluation scenario made up of four tasks described in Table 2.

Table 2: First scenario: tasks to be realised

Tasks to be realized	Theoretical duration of the task	Task description
T1	45 seconds	Send a message to the station " Gare SNCF " of the tramway line: *Stop of the next tramway 2 minutes in the station*
T2	45 seconds	Send a message to the tramway driver N° 6: *Stop 2 minutes in the next station*
T3	60 seconds	Send a message to all the stations of line 16: *Disrupted traffic because of a manifestation*
T4	60 seconds	Send a message to all the vehicles: *Merry holidays*

Let us note that theoretical durations necessary to the realization of the tasks are approximate durations. They are determined by a supervision expert initiated with the SAI.

Scenario 2: evaluation of the IAS in disrupted running mode

In the reality, in disrupted running mode, analyses showed that the task of the human regulators amounts to react by regulation actions to the warning, abnormality or breakdown messages from the system. By regulation action, we mean the information sent by the regulator and which is intended for the vehicles drivers and for the travelers in both stations and vehicles.

To make sure that the user (subject) interacts easily with the IAS by making regulation actions, we propose the second scenario which is complementary to the first one, and composed by four tasks described in Tables 3 and 4.

It is noticeable that the duration between the appearances of two messages is relatively short; this is not a fate. Indeed, we wish to put the user in a situation close to the reality where several

Table 3: Second scenario: messages displayed to the subject

Time	**Kind of message**	**Message from the *Exploitation Assistance System (EAS)***
t = 15 seconds	warning	Message 1: *the vehicle N° 4 line 16 is in advance of 5 min*
t = 35 seconds	warning	Message 2: *the vehicle N° 2 line 17 is late of 5 min*
t = 1 minute	breakdown	Message 3: *the vehicle N° 4 line 16 is out of order*
t = 2 minutes	abnormality	Message 4: Incident on the line Tramway near the Gare-SNCF station

Table 4: Second scenario: tasks to be realized

Tasks to be realized	**Theoretical duration of the task**	**Task description**
T1	55 seconds	Send a message to the vehicle driver N°4 line 16: *Stop 2 minutes in the next station*
T2	55 seconds	Send a message to the vehicle driver N°2 line 17: *You are late, please accelerate if possible*
T3	2 minutes	• Send a message to the passengers of vehicle N°4 line 16: *Out of order bus, arrival of the next bus in 15 minutes* • Send a message to the vehicle driver N°4 line 16: *The breakdown service arrives in 10 minutes* • Remove the vehicle from the network
T4	1 minute	Send a message to concerned stations: *Disrupted traffic: accident on the tramway line*

incidents can arise simultaneously within the network.
Contrary to the first scenario, the execution of the tasks is not sequential. Indeed, the beginning of each task is announced by an alarm or warning message.
In every appearance of a message of the Table 3, the user has to perform the task of the corresponding regulation. The Table 4 shows the tasks to be realized for each received message. The theoretical durations necessary for the realization of the tasks are determined by an expert in supervision initiated to the IAS.

5 Results

The five subjects carry out the various tasks envisaged with the two scenarios. The experimental device used enables us to collect (1) objective data by means of the electronic informer (MESIA) and (2) subjective data via the verbalization and the fillings of the questionnaire. We present in what follows some relevant results.

5.1 Results of the first scenario

The Table 5 presents a summary of the real average duration of each task in the first scenario as well as the success rate of its realization.

Table 5: Result of the first scenario

Tasks to be realized	**Real average duration of the task**	**Success rate of the task realization**
T1	41 seconds	100 %
T2	39 seconds	100 %
T3	67 seconds	(3 subjects out of 5)
T4	75 seconds	(3 subjects out of 5)

The results displayed in this Table 5 indicate that all the subjects carried out well the first and the second task with an acceptable realization average time; whereas, for the third and fourth task, only three subjects out of five could complete them. We also notice that the real realization duration of these two tasks exceeds the average. Indeed, this can be explained by the fact that the subjects are not experts in regulation.
To understand better the results obtained in Table 5, we can compare the model of the performed task and the model of the task to be realized. We take as an example the task T3 presented in Table 4.
Figure 4 shows:

- the model of the task to be realized (part a),
- the model of the performed task, successfully, by the subjects 1,3 and 5 (part b),
- the performed task, with failure, by the subject 4 (part c),
- the performed task, with failure, by the subject 2 (part d).

The Petri nets presented in Figure 4 show that the subjects 2 and 4 failed to achieve their task. Indeed, both subjects cannot reach the *view Message*. The subject 2 is blocked in the *view Station* and the subject 4 is blocked in the *Vehicle view*. This report confirms the results of Table 5.
This problem of blocking can be seen as a usability problem. Indeed, the results obtained after the evaluation of the IAS with the first scenario reveal that the IAS does not allow an intuitive and easy access to the *view Message*. We shall see farther some improvements related to the *State of the line view* which aims to introduce a specific message sending zone (cf. figure 5). This zone will allow the user to reach directly the Message view without having to access to the *Station view* or the *Vehicle view*.

5.2 Results of the second scenario

The five subjects realized the four tasks foreseen in the second scenario. Table 6 (obtained thanks to the electronic informer) presents a summary of the real average duration of every task as well as the rate of success of its realization.

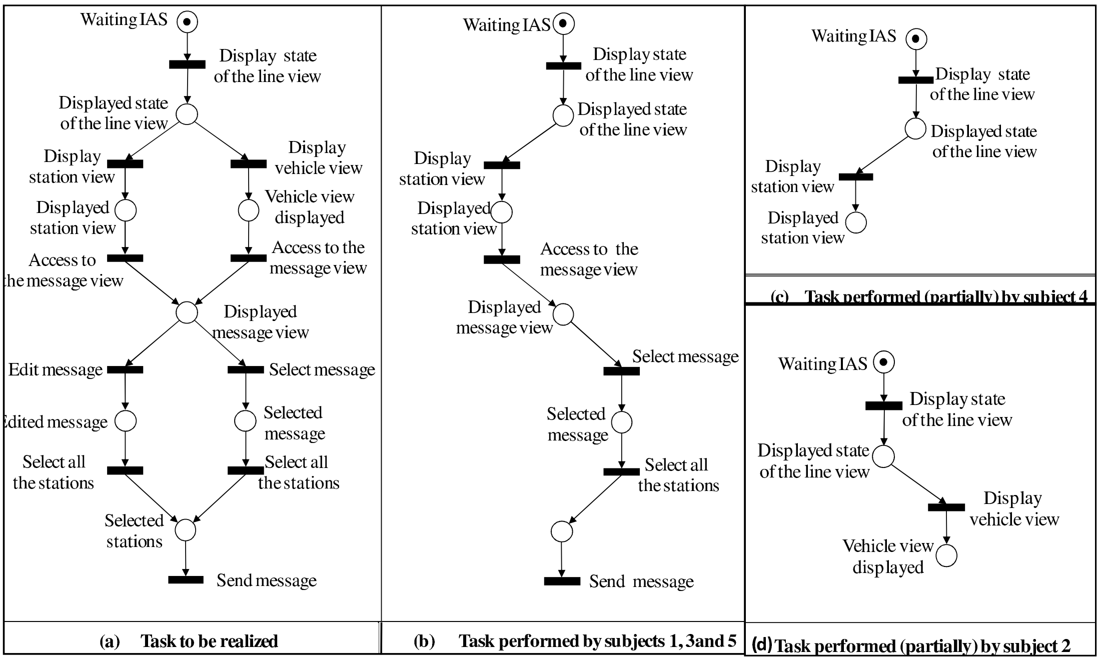

Figure 4: The model of the task to be realized and of the performed task (task 3, scenario 1)

Table 6: Result of the second scenario

Tasks to be realized	Real average duration of the task	Success rate of the task realization
T1	1 minutes 10 seconds	100 %
T2	1 minutes 30 seconds	100 %
T3	3 minutes 20 seconds	100 %
T4	1 minutes 25 seconds	100 %

The obtained results show that the five subjects succeed to achieve the four tasks proposed. However, we note an overtaking of theoretical time foreseen to perform the four tasks to be realized. This observation finds an explanation in the collected data with the verbalization. Indeed, all the subjects, without exception, point out that it is impossible to them to memorize messages from the exploitation assistance system (system in which the position and state of each vehicle are stored [6]). Besides, the IAS jams until the user validates the message; the user is thus obliged to memorize the message or to note it.

Besides, the Petri nets reconstruction of the performed tasks did not reveal any particular problem.

Other results are available in [23]. They lead to several improvements resumed below.

6 First IAS improvements

Regarding the results of the IAS evaluation obtained with the two suggested scenarios, the answers to the questionnaire and the verbalization, we propose improvements of the IAS mainly relating to the views of *State of the Traffic*, *State of the Line* and *Message* interface agents.

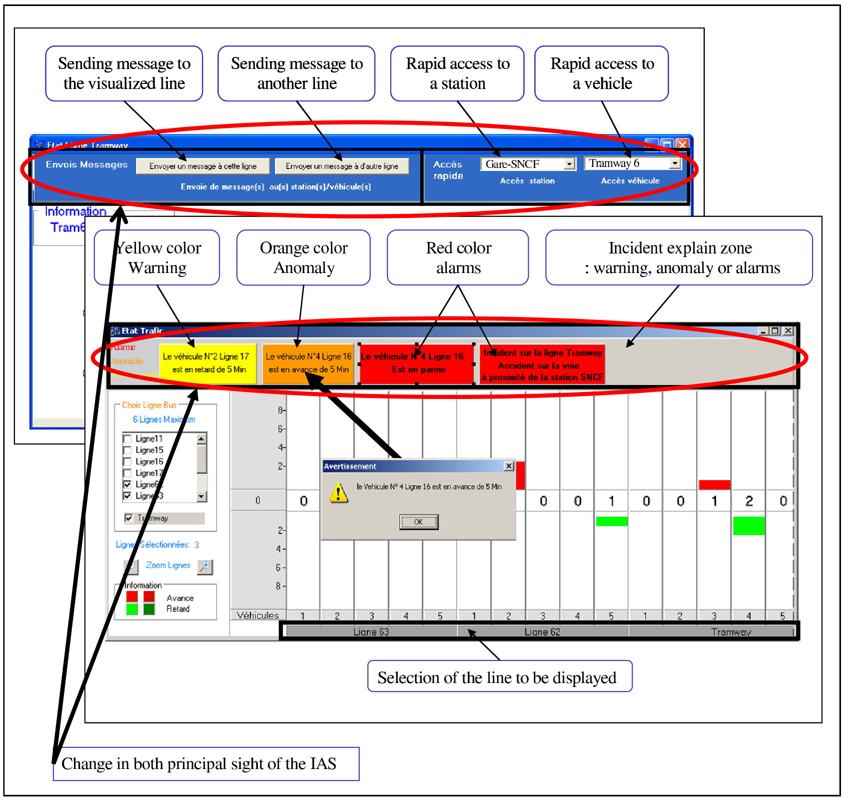

Figure 5: Improvement given to both interfaces: *State of the Traffic* and *State of the Line*

6.1 Improvement relating to the *view of State of the Traffic* interface agent

For a better usability, we propose to introduce (in top of the window) a specific zone to the alarm, anomaly and warning messages. In fact, when a message appears, the user takes note of it and validates it. Thus, instead of being lost, the message could be placed automatically in the message planned zone. In this way, the user would not need more to memorize messages or to note them on paper. This way of presenting the messages would make it possible the user to one by one treat them and to remove them once treated.

6.2 Improvement relating to the *view of State of the Line* interface agent

To solve the problem related to the message sent to the stations and the vehicles, we propose to introduce with the view of *State of the Line* interface agent a specific zone for the sending of message (see Figure 5). This zone would make it possible the user to reach directly the *Message* view without having to pass by the *Station* view or the *Vehicle* view.

6.3 Improvement relating to the *Message* interface agent

After the changes carried out on the view of *State of the Traffic*, the view of *Message* interface agent should be also changed. Indeed, if the user wishes to send a message to the whole of the stations of a specific line, it would be interesting to mask the information relative to the unconcerned lines.

6.4 Other possible improvements

In addition, we note, during the evaluation, that the messages edited by the user are not recorded by the IAS. Indeed, if the user wishes to send the same message twice, he or she has to reedit it.

7 Conclusion

We have presented in this article the results of a first evaluation of an Information Assistance System. This system is based on an agent-based architecture. This evaluation has been performed in laboratory and provided us with interesting results. The evaluation dealt with two different scenarios. It was then possible to deduce from it first proposals for an improvement of the IAS.

Our further research aims, on the one hand, to the improvement of the Simulation modules/Confrontation/Specification and generation of Petri nets (see [30], [29], [28]) and, on the other hand, a second evaluation on the ground which proves to be necessary for the detection of the utility and/or usability problems not detected during the first evaluation. The eye tracking technique [18] could be used to go deeper in the second evaluation.

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