A PROPOSED REGULATION STRATEGY FOR AN URBAN TRANSPORTATION SYSTEM

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ABSTRACT

Many works proposed decision support system for the regulation of an urban transportation system. But, to our knowledge, it does not exist systems which propose a real interaction between the regulator and the decision support system. Indeed, the majority of its systems tend to automate procedures of regulation, which go in opposition even to the definition of an interactive system of decision support system.

We propose in this article the identification of the decision-making process of the regulator in its Centralized Unit Control Unit Centralized (CUC) in order to offer to him, in the phase of design, the possibility to construct the solution of regulation by carrying out the choice between various strategies in the aim to ensure a complete interaction between him and the Decision support system for regulation.

Key words *– Urban transportation system (UTS), Decision Support System for Regulation (DSSR), algorithms of regulation, cognitive engineering, Automatic Monitoring vehicle (AVM).*

I. INTRODUCTION

The work presented in this article aims to improve the quality of service (comfort, regularity, punctuality) to increasingly demanding users with respect to their person receiving benefits who are the companies of transport. Thus, to ensure the regularity of the traffic forces them to set up the means of identifying the dysfunctions disturbing the traffic and of removing or of attenuating their impacts on the operation of the transportation system.

The proposed DSSR is an environment of supervision for the regulation of a bimodal urban transportation system. It is based on the regulation operator decision-making process and allows him to identify the disturbances and to evaluate the potential actions of regulation to engage according to the strategies of regulation which it chose. For this purpose, an algorithmic formalization of a certain number of actions of regulation is proposed at ends of automation. Thus, the regulator does not deal any more of the parameter setting with the actions of regulation for the various vehicles on the network; in fact the DSSR proposes to him the replanning of the portion of the network implied in the disturbance.

The first part of this study is devoted to the identification of the decision-making process of the regulator in its CUC, like to the proposal of the functional model of the phase design of the solution. We will give then, through an example of algorithm how we proceeded to automate the various actions of regulation. Lastly, we present in detail the three strategies of regulation adopted by the DSSR with an example to illustrate our step.

II. REGULATION

The regulation of the traffic is a complex task, where the decisions are made according to the state running of the transportation system. The owners of the network encounter many difficulties to maintain a traffic in conformity with estimated planning (database theoretical timetable) and to comply with the rules of use (rules of regulation, safety requirements, commercial role of the company…). The difficulties are due to various types of disturbances which can affect the operation of the line and give its randomness to him. These disturbances are related to the conditions of circulation, the traveling material, the variations in the configuration of the request for transport or caused by the conducting personnel and finally to the errors in the application of the database theoretical timetable [2].

III. MODEL OF THE DECISION-MAKING PROCESS OF THE REGULATOR

The work undertaken in the field of the computerized decision-making systems in regulation of urban transport is interested mainly in the automatic development of algorithms. A comparative study of the various systems as well as the models of the operator was proposed in [2].

III.1 PROPOSAL FOR A PROCESS MODEL OF DECISION FOR THE REGULATOR OF AN URBAN TRANSPORTATION SYSTEM

The aim of the regulator is to ensure the regularity of the traffic, i.e. to make so that the various vehicles of one or more lines respect the theoretical schedules defined in the theoretical timetable. The regularity of the traffic is affected by several types of disturbances identified as being mainly the delay, the advance or the immobilization of the vehicle.

The regulator to achieve its tasks of monitoring, diagnosis and treatment must not only consider the variations of time of each vehicle compared to its theoretical course, but also take into account the relationship and interactions between vehicles of the same line (regulation in lines), different lines (correspondences), anticipate the evolution of the disturbances according to the rates of travel and evaluate their impact on the operation of the network.

Consequently, the regulator is not only a "reactive agent", but also a "solvor" of problems [5]. It can call on the DSSR if necessary which will provide it solutions or will help it to build them. These considerations led us to propose this process model of decision, of the regulator of an urban transportation system, figure (1), inspired from the work of Rasmussen and Hoc [9] and Millot [11]. In our case, there is no conflicts situation between the DSSR and the regulator because this one entirely controls the development of the solutions to the disturbances.

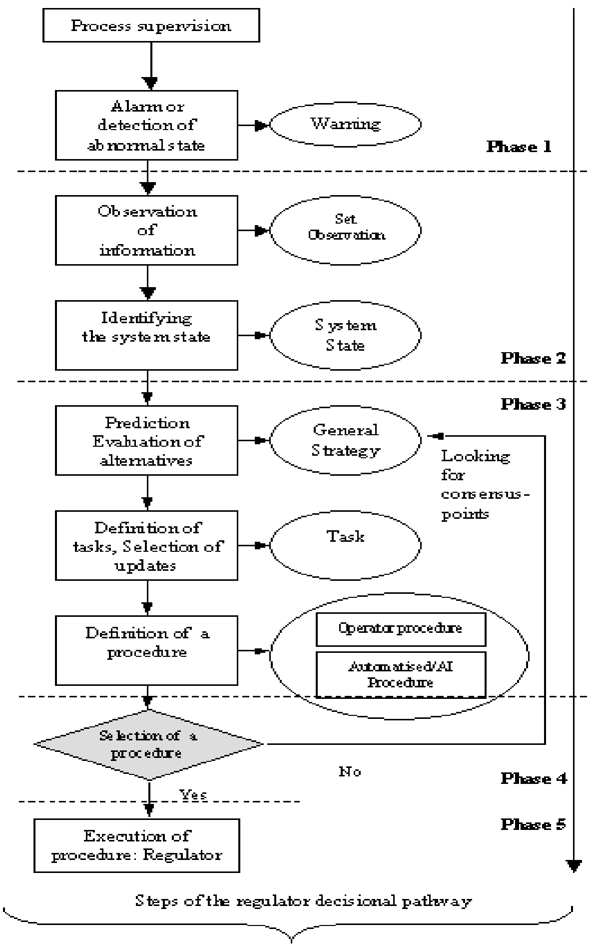

Figure 1: Synthesis of the decisional pathway adapted to the regulator of an urban transportation system

The first phase corresponds to the acquisition of the disturbances, the second to the analysis of the disturbances, the third phase to the construction of solutions (design), the fourth to the evaluation of the obtained solutions, and finally, the fifth phase to the implementation of the solution adopted by the regulator.

We particularly are interested in the third phase "construction of the solutions" in which the DSSR offers three distinct strategies to ensure the regulation.

Each one of its strategies exploits directly or via approaches of the artificial intelligence a panoply of algorithms of regulation. The regulation can be effective only after the choice of one or several disturbances to be controlled by the regulator. Figure 2 shows the functional model of the phase design of the solutions.

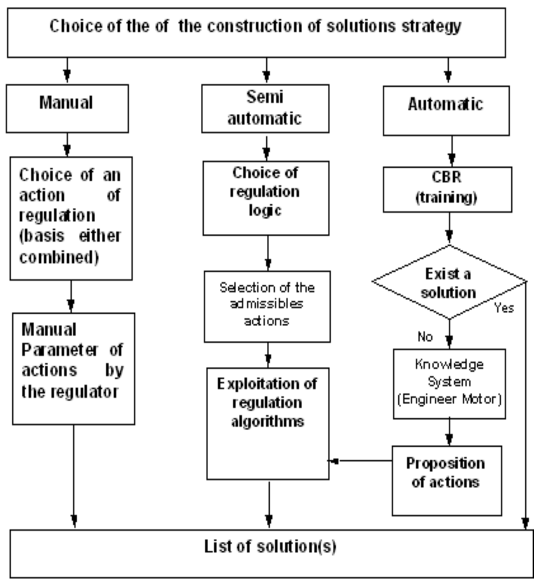

Figure 2: Functional model for the construction of the solutions: Interaction of the components of the module

A real interaction is established between the regulator and the DSSR. The regulator can choose between three methods of construction:

- a manual mode: the regulator is the only person in charge for its decision-making; he makes the choice of one or several actions of regulation constituting a solution with the disturbance in progress.
- a semi-automatic mode: the regulator chooses one or more logics of regulation (removal of the load, punctuality, schedule, correspondence). This choice allows the DSSR to filter the nonacceptable actions and to

propose with the regulator those on which it can support its decision-making.
- an automatic mode: no intervention of the regulator is necessary; the solutions are proposed automatically by the system.

The various components of the module of regulation interact as follows:
- The algorithms of regulation are exploited
  - by an inference engine following the validation of the regulator of a proposal for an action of regulation (automatic mode),
  - by the regulator following the choice of an acceptable action after having privileged a logic of regulation (semi-automatic mode).
- On the other hand, in manual mode, the regulator when it chose an action of regulation, it is with him falls to make the parameter setting.

IV. ALGORITHMIC FORMALIZATION OF THE ACTIONS OF REGULATION

Thus, we formalized the set of the suggested actions [12] except for the on-line regulation and of the regulation in terminus presented in [7]. The appendix (1) proposes the formalization of two of these actions implemented in the DSSR. In what follows, we are interested in the three strategies of construction of solutions to knowing: manual, semi-automatic and automatic mode. This last mode directly exploits the algorithms proposed [4].

V. REGULATION IN MANUAL MODE

The manual mode makes it possible the regulator to build himself its strategy of regulation. Indeed, the DSSR put at its disposal a panoply of actions that it has the possibility to select it, and inform the values of the various parameters of them. This mode is necessary when a regulator is confronted with a no familiar situation for which the automatic mode would not have proposed any solution to him. This mode is also recommended for the experience sharing between regulators. Thus, a situation met by one is thus safeguarded in the base of the cases and can be reemployed by another regulator confronted with the same disturbance. The manual mode proposes a panoply of actions of regulation. These actions are classified in 2 categories:
- Basic actions of regulation
- Combined actions of regulation, table (1)

The difference between the basic actions and the combined actions is that these last are complete procedures implementing basic actions according to a preset order.

V.1 CHOICE OF THE LIST OF THE ACTIONS TO BE ENGAGED

As soon as the regulator chose the manual mode for the regulation, he will have to choose the class of actions, he wishes to operate with. Then, it carries out the choice of one or several basic or combined actions. This choice requires on behalf of the regulator to parameterize by itself the actions for their implementation. We present the list of the headings below to be informed for each combined action.

Algorithm actions_combinées (ChoixAC)
Begin
According to ChoixAC make
ChoixAC = "Direct on line"
Begin
Select Station taken then (name of station);
Select time of recovery (time recovery)
End
ChoixAC = "Half-turn on line"
Begin
Select vehicle to be transshipped (number vehicle);
Check load of transshipped vehicle;
 If load <= capacity vehicle **Then**
 carry out "transshipment";
 Endif
Indicate delay of preceding vehicle (duration);
Indicate delay of the next vehicle (duration)
End
ChoixAC = "Half-turn with exchange conducting and available"
Begin
Select vehicle to be transshipped (number of vehicle);
Check load of transshipped vehicle;
If load <= capacity **Then**
Carry out "transshipment"; the emptied vehicle sets out again HLP[1]
Repositioning the emptied vehicle (select the station or the terminus of repositioning);
Select time of recovery
Endif
End
ChoixAC = "overtaking and service in descent only"
Begin
Check availability (conductor/vehicle);
If Available **Then**
Update list of the availabilities;
Select station taken again disturbed vehicle (station name);
Select time of recovery disturbed vehicle (schedule of recovery)
Else
write ("action impossible to realize");
Endif
End
ChoixAC = "......."
…

[1] HLP: the vehicle circulates non-stop and without travelers.

End
Update Timetable
End.

VI. REGULATION IN SEMI-AUTOMATIC MODE

For the semi-automatic mode, we have recourse to a process of filtering. This process is based on the adequacy of the actions with various logics. There are four different logics related to the transport configuration: the logic of removal of the load, the logic of regularity, the logic of punctuality, and the logic of correspondence.

Name of actions	Punctuality Logic	Regularity Logic	Correspondences logic	remove of the load logic
Deviation				Yes
The on-line express		Yes		
The on-line half-turn				Yes
The half-turn with drivers and vehicles exchanges				Yes
overtaking and service in descent only	Yes			
departure delayed in the terminus		Yes	Yes	
The drivers and vehicles exchanges		Yes	Yes	
The shortcut	Yes			
Injection of a reserve and an available	Yes	Yes	Yes	Yes
on-line regulation		Yes	Yes	
regulation in terminus		Yes	Yes	

Table 1: Compatibility actions/ logic of regulation

As soon as the regulator chose a logic, the DSSR carries out a filtering and proposes with this one only the actions of regulation compatible with its choice according to table (1). The choice of an action of regulation by the regulator determines the algorithm which will be exploited and which will ensure the automatic parameter setting of this one.

VII. REGULATION IN AUTOMATIC MODE

As represented in the figure (2), the Case based Reasoning CBR [13] makes it possible to exploit cases of disturbance already treated and which are characterized by a certain similarity with the current disturbances (lately acquired). The DSSR requested by the regulator seeks in the case-base a similar disturbance in order to propose its solution. If the CBR finds a solution in the case-base all calculations of setting parameter of the action are remade according to the context of the new disturbance. If the CBR does not propose any solution, the Knowledge system (inference engine) takes the task to find solutions, figure (2).
The inference engine is designed in such way to reproduce in the form of production rules the set of the listed actions of regulation. As soon as the conditions are met, it proposes the actions of regulation identified for the disturbance in progress.

Then the action retained by the regulator is implemented directly by the DSSR by exploiting the corresponding algorithm.

The classification of the actions of regulation suggested in table (2) is adopted by the inference engine in order to optimize the proposals solutions. The works presented in [1] [6] [8] [10] were interested rather in classification of the disturbances. The interest is related to the classification of the actions of regulation by comparing them on the basis of three criterions relating to the period of the day, the adequacy with other actions and the existence of transshipment. This comparative study has for aim to clarify the interest of each action suggested compared to the set and to determine complexity [4] of it.

Name of actions	**Period of day**	**Adequation with other actions**	**Trans shipment**
Deviation	off-peak or peak hours	On line regulation, regulation in terminus	No
The on-line express	off-peak hour	Out itinerary line	No
The on-line half-turn	off-peak or peak hours	-	Yes
The half-turn with drivers and vehicles exchanges	off-peak or peak hours	-	Yes
overtaking and service in descent only	off-peak or peak hours	Half-turn of the delayed vehicle	No
departure delayed in the termi nus	off-peak hour or peak hours	-	No
The drivers and vehicles exchanges	off-peak or peak hours	The empties vehicle parts HLP	Yes
The shortcut	off-peak	-	No

	or peak hours		
Injection of a reserve and an available	off-peak or peak hours	HLP	Yes
on-line regulation	off-peak or peak hours	-	No
on-line regulation	off-peak or peak hours	on-line regulation	No

Table 2: Comparative study of the regulation actions

VIII. INDICATORS OF EVALUATION

For the evaluation of the solution, the regulator is pressed on several indicators worked out by the DSSR. These indicators are structured in two categories (essential and important). The essential indicators as the indicators of punctuality, regularity and correspondences were the subjects of various studies [6] [8] [10] [12]. On the other hand, the important indicators as the indicators of satisfaction of the passengers and the commercial cost of the adopted solution were presented in [2] and formalized in [3].

IX. EXAMPLE OF SCENARIO

To illustrate the operation of the DSSR, we present a simplified example of management of a disturbance affecting the network of the town of Oran city. We include in this example, the set of the decision-making process of the regulator as known the five phases, figure (1).

Phase 1: A disturbance is detected to 09: 47 on the line N° 11. The disturbance is a delay of 11 min due to congestion. The affected bus by the disturbance is N° V25. The next station of the line is the station “El Hayat” located at 505m of the position of the late bus.

Phase 2: In complement of information received from the AVM, the DSSR provides to the regulator following information (information context):
- the disturbance takes place in hollow period,
- the vehicle following the bus N°25 is with 27 min,
- the load of the disturbed vehicle is of 11 customers
- the bus must ensure several correspondences (line 51, 34),
- priority of treatment of the disturbance = 10 (weak gravity).

Phase 3: the regulator treats the disturbance and chooses a regulation in semi-automatic mode (It is about a routine disturbance which intervenes in hollow period, the load of the vehicle is minimal, which implies a weak dissatisfaction with the travelers). The selected regulator to respect a logic of regularity. The DSSR starts the filtering of the acceptable actions systematically and proposes with the regulator the following list: □ departure delayed with the terminus, □ exchange drivers vehicles, □ regulation on line, □ regulation in terminus. The regulator chooses a regulation on line because it judges it likely not too affected operation of the network. It is a question of distributing the delay on the vehicles upstream and downstream from the disturbed vehicle.

Phase 4: The action selected by the regulator gives like evaluation: - a number of travelers on standby in increase of 13% for the following vehicle, a loss in punctuality of 39% compared to the theoretical value.

Phase 5: the implementation of this action indicates to the regulator following reconfiguration various vehicles implied in the regulation (vehicles which circulates in the same direction):
- V25 continues its route normally,
- to delay each vehicle upstream and V27 downstream, V28 and V26, 4 minutes (Constraints propagation),
- the schedule of the nearest starting station “ Central Police station” of V27 is 09:51
- the schedule of the nearest starting station “Medina Djedida” of V28 is 09:54: 33
- the schedule of the nearest starting station “ City of the girls” of V26 is 09:51:08
- recovery hour of the “University Es-Sénia” terminus of V27 is 10: 17: 16
- recovery hour of the “Place Valéro” terminus of V28 is 10: 06:10
- Horaire recovery of “Place Valéro” terminus of V26 is 10: 26: 04

The schedules suggested by the DSSR are extracted from TM.

Note:
The set of this information: nearest starting schedule station and schedule of recovery to the terminus are obtained by the means of the implementation of the algorithms proposed in the DSSR.

IX. CONCLUSION

The regulation of the urban traffic requires a complex process for which a decision-making system must bring to the regulator information and the relevant tools for evaluation. We proposed an interactive system for regulation (DSSR), based on a model of the decision-making process of the regulator resulting from cognitive engineering. We proposed the functional model of the phase design of the solution as well as examples of implementation of the algorithms of the actions of regulation exploited in semi-automatic mode. We identified the parameters to be informed by the regulator for the manual mode and the step to be followed in automatic mode.

The hard actions [7] formalized such as the half-turn on line with exchanges of drivers and vehicle, the direct one on line or the half-turn on line are complex actions which induce various operations from where the time wasted by the regulator to indicate to the drivers the step and the new positions and schedules to be respected. From which our interest to formalize them and to implement them in a DSSR. Let us note in addition, that any solution is implemented if it was not validated as a preliminary by the regulator.

X. REFERENCES

[1] Balbo. F., 2000. ESAC : Un modèle d'interaction Multi-agent utilisant l'environnement comme support actif de communication : Application à la gestion des transports urbains. Thèse de doctorat, Université PARIS IX Dauphine, 28 janvier 2000.

[2] Bouamrane, K., T. Bonte, M. Sevaux, and C. Tahon, 2005. SART : un système d'aide à la décision pour la régulation d'un réseau de transport bimodal. MHOSI'2005, Hammamet (Tunisie) 24-26 Avril 2005, pp187-192.

[3] Bouamrane, K., C. Tahon, B. Beldjilali, M. Sevaux, 2005. "Decision-Making system for regulation of a Bimodal Urabn transportation Network, associating a classical and Multi-agent approaches ", INFORMATICA International Journal, December 2005, Vol 16, N°4, pp 473-502.

[4] Bouamrane, K., C. Tahon, H. Sefiane, 2006. "Régulation d'un réseau de transport urbain : Formalisation des actions de régulation et Raisonnement à partir de Cas ", actes de la 6e conférence francophone de modélisation et simulation- mosim'06 - du 3 au 5 avril Rabat–Maroc "modélisation, optimisation et simulation des systèmes : défis et opportunités ".

[5] Boy, G. Supervision et coopération homme-machine : approche système. In G.Boy (Ed), Ingénierie Cognitive IHM et Cognition, Chapitre 6, pp 191-221, Hermès Paris, France, 2003.

[6] Chihaib F.B., 2002 Approche floue pour la régulation multimodale dans les réseaux de transports urbains en mode perturbé. Thèse de doctorat, Université de Lille.

[7] Cure, C., and B.Foraste, 1984. Système d'aide à l'exploitation et algorithmes de régulation. Revue Recherche Transport Sécurité, pp 14-22, Juillet 1984.

[8] Fayech, B.C, 2003. Régulation des réseaux de transport multimodal : Systèmes Multi-agent et algorithmes évolutionnistes. Thèse de doctorat, Université de Lille.

[9] Hoc, J.M. Supervision et contrôle de processus, la cognition en situation dynamique. PUG Grenoble, France, 1996.

[10] Laichour, H., 2002. Modélisation Multi-agent et aide à la décision : Application à la régulation des correspondances dans les réseaux de transport urbain. Thèse de doctorat, Université de Lille.

[11] Millot, P., Taborin V. et Kamoun, A. Two approaches for man-computer cooperation, In supervisory tasks. 4th IFAC Congress on Analysis Design and Evaluation of Man-Machine Systems. Xian, Chine, 1989.

[12] Ould Sidi, MM., S. Hayat, S. Hammadi and P. Borne. 2005. Urban transport Disrupted networks regulation strategies making and evaluation : A new approach », IESM' 2005, 16-19 Mai, Marrakech (Maroc).

[13] Pasquier, L., 2000. Modélisation de raisonnements tenus en contexte. Application à la gestion d'incidents sur une ligne de métro. Thèse de doctorat LIP6.

[14] Semurval, 2004. Document de la Semurval sur les actions de la régulation, reçu le 29 janvier 2004.

APPENDIX 1.

For the set of the algorithms proposed, table (3) presents the input data with their source of origin.

Variable name	***Significance***	***Source***
Period	***period of the day (hollow or of point),***	DSSR
retard	***delay considered caused by the disturbance***	***AVM***[2]
Frequency	***frequency of the line or interval separating the two vehicles V_1 and V_2***	***TM***
LigneP	***number disturbed line***	***AVM***
HP	***Schedule of disturbance***	***AVM***
NumAP	***number stop disturbance***	TM
Capacitéi	***capacity of the vehicle, i represents the index of the vehicle***	Vehicle characteristics (DSSR)
TempsB	***time of beat***[3]	TM
Panne	***the disturbed vehicle is broken down***	AVM

Table 3: Variables in entries for the algorithms of regulation

[2] AVM : electronic device for the capture of the data network.
[3] Time of beat: is fixed for each line, on average it is equal to 10% of the total duration of the way.

The output data and the functions used are identified on the level of each algorithm proposed in the form of procedure. In order to illustrate our works, we propose the algorithm corresponding to the action "direct on line".

a) Direct on line

Definition:

The vehicle follows the route of the line by ensuring only the stops of descent for the customers on board. It takes then a normal service (rise and descent of travelers) as soon as the delay is reabsorbed, figure (3).

Schematic description

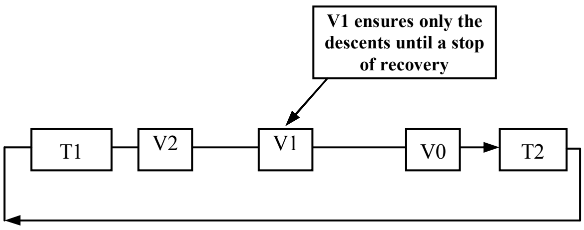

Figure 3 : Schematic representation of Direct on line

Used Function

Arret_reprise(Retard, numéro_arrêt_perturbation, numéro_ligne_perturbé) : function allowing to turn over the stop of recovery of V_1**.**

Procedure DirectEnLigne ***(Input*** *: V1, HP, LigneP, Retard, Période, NumAP* ***; Output*** *: HR, NumAR)*

Début

If (V_1 has Retard $\in$ [2, 4] min) ***Et*** (Period = « Hollow ») **T*hen***

NumAR = ArretReprise (Retard, NumAP, LigneP) ;

V_1 continues its route by ensuring only the stops of descent until a stop NumAR;

determine time of recovery HR of V_1 in stop NumAR from TM[4]

EndIf

End.

Function ArretReprise (*Retard, NumAP, LigneP****): String***

Var N; // number of stops to be served only in descent;

Begin

N = Retard / (half of the latency per station)[5] ;

NumAR= NumAP + N ;

If NumAR < T2

Then return

(Seek in TM, the stop NumAR of the line LigneP)

Else return (T2)

endIf

End.

[4] TM : table of the stops with corresponding schedules (Timetable).

[5] The latency per station is supposed to be fixed for each the set of the netwok station.