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Managing the Incidents in the Urban Transport

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Abstract. The multi-agent systems, their efficiency, the main characteristics and their approaches are reviewed. The market mechanism that will be used in the proposed model is also analyzed. Is shortly introduced a model for incidents and intervention in urban transport. The agents that intervene in incident solving are given and an analysis of incident origins is presented.

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1. Introduction

The requirements for urban public transport need appropriate and efficient tools. The multi-agent systems [8], [4] and intelligent systems [11], [12], [16] are a useful mean in a lot of application domains. In the last decades were conceived and implemented many systems traffic management.
Simulation is frequently used in systems design and it offers a powerful tool. Were introduced Simulation of Intelligent TRAnsport Systems (SITRA) [9] a massive multi-agent simulation system, in which driver vehicle objects are modeled as autonomous agents. The simulation outputs can be used for the evaluation in congestion and incident management, dynamic route guidance. The forced and cooperative lane changing model [9] can produce realistic flow-speed relationships during congested conditions.

Some systems that were developed show that the opportunities for cooperation between dynamic traffic management instruments. Agent technology is presented as a useful way to support the deployment of it [8], [13], [14]. In complex systems more and more instruments are deployed, chances are that conflicts will arise when control tools are applied in the same area. By modeling the instruments as intelligent agents, it might be possible to tune the actions of the individual instruments through the agent concept of collaboration. The incident detection algorithms [17], [18], [19] are a main tool in such systems model. These algorithms are designed ad implemented for quickly detecting incidents. The algorithms use various methods like wavelet technique, delay based and support vector machine are used.

The aim of the paper is to define kind of intelligent agents for solving the incidents in traffic, for urban public transport. The paper is organized as follows. In the next section, are made some considerations on the multi-agent systems and are reviewed some particular implementations. Market mechanism [6] is shortly analyzed and it will be used in future work for implementing the proposed model for Incidents and Intervention in Urban Transport that is given in the next section. The main concepts are given by some definitions that will be used in the model future evolution. The last section, Conclusions traces the future development of the proposed model.

2. Market mechanism

In the following the market architecture [5], [6] is shortly analyzed. An economy is essentially a population of agents producing a global output. The agents coordinate with each other to produce an aggregate set of goods. Based on the many reasons between we cite the following:

- centralized economy has the inability to gather all salient information, uncertainties in how to optimize it and inability to responding to changing conditions;
- often the economic output is divided equally amongst the entire population, with predictable implications (individuals have a little incentive to work more efficiently); individual input is not coupled with individual output.

A free market economy is more efficient. Individuals are often in the best position to understand their needs and the means to satisfy them. The individuals reap the direct benefits of their own good decisions and suffer the direct consequences of their bad ones. They cooperate with other members of the society to achieve an outcome greater than that possible by each member alone. Also they compete with other members to provide services at the lowest possible cost. Based on these, the individuals act only to advance their own self-interests, the aggregate effect is a highly productive society. In multi-agent systems, the task of agent coordination is based on such mechanisms. The one of the main aspects is that the agents are self-interested. It must outline that the agents can be self-interested only within the domain of capabilities allowed to them. Designing appropriate cost and revenue models it is not trivial in some application domains. Some main features are the following: determining revenues and costs; the role of price and bidding process; cooperation vs. competition; self organization; learning and adaptation.

One of the greatest strengths of market economy is the ability to deal successfully with changing conditions. Since the economy does not rely on a hierarchical structure for coordination and task assignment, the system is highly robust to changes in the environment, including failure of agents. Usually disabling any single agent should not jeopardize the system performances.

3. A Model for Incidents and Intervention in Urban Transport

3.1 Urban Transport Systems

A real urban transport system contains many transport types. A specified transport type moves on a line that has some common segments with other ones. General objectives of urban real systems under the two antagonist criteria are:

- optimize the resources usage;
- time optimization regarding the passengers that use the system.

By its effects, the urban transport affects the daily life. A short analysis allows emphasizing the components that act in the system. These components are trains (trams, trolleys, and buses), lines, stations intervention tools, personnel.

The traffic is affected by incidents [17], [18] that have a major influence on the traffic flow. One of the main objectives consists from immediate sensing and discarding the effects of the incidents. The influence of incidents on the traffic flow must be carefully managed. One of the solutions consists from modeling of the system by a multi-agent system that provides the requirements imposed by the real system.

A multi-agent system that manages the public transport contains set of agents that cooperate in order to improve all the requirements concerning the efficient usage of resources and the comfort of passengers. The detailed system design is not given here and is not the aim of this paper. In this paper only some types of agent are detailed.

The needed information is obtained based on appropriate sensors and is placed into an appropriate data base: defines the structure of information and contains the information itself; systematic and in most of cases in real time recording; automatic processing including statistics.

Some of the system functions are: automatic generation of documents for "field" (data) recording; planning the daily traffic; simulation; periodic reports; optimization upon specific criteria.

3.2 Incidents and their Management

The incidents that appear and disturb the normal flow of the traffic are:

- a- Failure of Train/bus;
- b- Partial Failure of Train/Bus;
- c- Absence Source of Motion essence/electric current, for a specified train;
- d- electric Cable Broken, with the coordinates of the point where the cable is broken;
- e- Rail Broken with the coordinates of the point where the rail is broken;
- f- ACCident with the coordinates of the point where the accident was produced;
- g- Line Deviation;
- h- Fire of a train.

For every kind of incident its attributes are specific and mainly the instant in time when the incident starts *ts* and the incident ends *te*.

The impact of the traffic on the system is specific for every incident. While the a-c incidents imply actions on the frequency on the line, the d-e incidents imply complex actions (like line deviation). The incident of type f has many meanings that concern the fact that our train was or not implied in the accident.

An incident e is a change of the normal state of a *LA/TA* (Line Agent/Train Agent) or both, that disturbs the normal traffic flow. It has the following attributes: *et* incident type; *aT* agent Type that generated the incident; *aid* agent identification that generated the incident; *ts / (ts, te)* start time/ time interval in that the incident acts; *tc* current time (timestamp), when the incident is analyzed if it is need; $imp = f_{aT}(aid, et, ts, tc, so)$ incident impact where *so* is the source of incident that can be *cb/rb/acc/ld*.

Depending upon the type of agent that generated the incident its function f_{aT} has a specific form. Also it must outline that the variables have different values in time (like the passenger number, etc).

The dynamic of the incident in time is illustrated by its impact that can be graphically represented in time. The impact value is quantified for all incident types and based on this the incidents are ordered. The action in an incident depends upon the resources available at an instant time and upon other incidents that are in turn. A produced incident is treated using appropriate tools (resources) that can be humans, cars, another intervention machines.

The incidents affect many of real system components and have major implications on the traffic flow and on the passengers. The incidents can appear simultaneously in the system. The effects of the incidents vary in a large range starting from a failure of a minor component part of a train, on affecting the traffic flow through traffic blocking. For discarding the effects of every incident type a specified set of actions are executed in specified time intervals. These actions use certain resources in given numbers (amounts).

The information (concerning incidents) is kept and processed in a specific manner for managing the incidents, their evolution in time and discarding their impact over the system. The impact of incidents on the system plays an important role. Depending on their gravity (impact on the system), on the resources available in a specified instant time, are done interventions for discarding the impact of the incident on the system.

Human operator that controls and manages the incidents and their resolution has a lot of difficulties:

- multiple active incidents in a specified time instant;
- resources are already implied in resolution of another incidents;
- do not disposes for an efficient tool that allow the incident evaluation.

In the next subsection model is proposed and shortly analyzed.

3.3 Proposed system model

The proposed system model contains many agents that are implemented on different computers that are connected. Many of computers work in a client/server architecture where every agent acts as a client or server upon needs. In a future system version the computers can communicate via Internet.

The lines and trains are agents (*LA* and *TA*) implemented on different computers, everyone having an appropriate data base. Other agents can execute some specific queries and can obtain in real time information that is necessary. The LA/TA agent acts as a server for the other types of agents that ask at every requirement returning its status.

When an incident appears it is sensed by an *LA*/*TA* agent and it instantiates an *Intervention Agent IA*. This agent treats the incident. After an *IA* agent was instantiated it acts as follows:

- evaluates the impact of the incident over the system. There is a delay between the instant when the incident appeared and the instant when the IA treats it. In this version of model the delay is not taken into account;
- searches for needed appropriate resources, based on the specific set of actions (it was shortly presented in previous subsection) depending on the incident type. The set of actions is modeled in an appropriate data base;
- negotiates with other IAs if these use the needed resources. Main tool in the negotiation process is the impact of the incident on the system. The market principle (presented in one of the previous section) is the basis for the negotiation;
- proposes to the human operator the solution;
- after the decision of the human operator updates the incident resolution;
- stores the incident evolution in a data base.

In the system there is a set of resources that have different types and that are used in resolution of incidents. For every resource type we dispose for a resource pool.

A resource R_i is a tool that has the following attributes: $id\,R_i$ - identification of the R_i; $ty\,R_i$ - resource type; $lsR_i = (ts, te), e_i$ a list where every item contains the time interval and the incident where the resource acts.

The resource has a function that returns its status:

$$staR_i(t) = \begin{cases} (idle, 0) \text{ idle at instant } t \\ (active, e_i) \text{ acts in teh incident } e_i \text{ at instant } t. \end{cases}$$

The $staR_i(t)$ - represents the status of the R_i at the instant *t*.

The incidents needs for resources that participate in eliminating its effects. These resources consist from R_i in specified amounts and for a defined time interval. For every incident type e_t the set of resources used in eliminating its effects is denoted by $Need_{et} = \{(R_k, am_k, (ts, te)), k = i_1, \ldots, i_{Net}\}$ where am_k is the amount of the R_k that is necessary to work for the incident type et and *(ts,te)* is the time interval in that the R_k acts. When the incident e_t is treated for eliminating its effects, the set $Act_{ei} = \{(R_k, am_k, ts), k = i_1, \ldots, i_{Nei}\}$ represents the resources that are in train of action at the instant *t* and *ts* is the time instant when the R_k started to act. At every instant of time *t* the rest of the work to be done for eliminating the effect of the incident e_t can be computed and also the final time ft_{ei} when all the rest of the work will be finished.

The *IA* agent sends a query. After the agent *IA* receives the answer, it examines the conditions that can define an incident and it starts to manage this incident.

The human operator using the proposed solution of the *IA*, analyzes it in the general context of the system and dispose for the *IA* s as final decision concerning the incidents that will be affected (by his decision). It implies that the *IA* s updates their managed incidents and re evaluate the own impacts. It is obvious to outline that some solution in turn of incidents (whose impact is considered to be minor) can be interrupted in favor of some incident that has the main (major) impact on the system.

4. Conclusions

Real systems require more and more tools for improving their requirements. The systems that use the multi-agent model often are implemented on a distributed computer architecture. Many agents are on the same host or there are agents that have their own computer depending on the agent complexity. The complexity of the agent actions is reflected in programs that become more and more complex and requires performance of computers.

The dynamics of the real world must be taken into account and it requires adequate tools and models. The proposed model based on multi-agent systems seems to be appropriate for urban transport systems.

The communication between agents depends upon the system and upon the agent actions. The communication traffic is variable depending on the system status. Solving the incidents that appear, the *IA*s overload the communication traffic of the system. It implies an efficient communication between the agents and it must be reliable.

In the proposed model data needed must be delivered in an efficient manner and it must be processed in a real time fashion. For that, all the IA functions will be conceived and implemented in order to improve its goals.

In the future versions of the proposed model we intend to:

- refine and detail the IA functions;
- design and implement an user (human operator) most friendly interface;
- define the abilities that allow to the agents to treat the failures and partial failures of the agents and the resources;
- communication between agents will be done via Internet;
- the delay between the instant when the incident appears and the instant when the incident is treated by IA will be analyzed and appropriate treated.

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