Extending microscopic traffic modelling with the concept of situated agents

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ABSTRACT
In the traffic simulation field, there is a general agreement that microscopic simulation is becoming more viable, improving the way in which system elements are represented. However, even with more powerful computational resources made available trading off between realism and too much abstraction is an important issue to overcome, as traditional micro-simulation approaches still fail to profit from all benefits that realism could offer to traffic modelling. In this work we bring this discussion forward and propose a multi-agent model of the traffic domain where integration is ascribed to the way the environment is represented and in which agents interoperate in microscopic simulations. While most approaches still deal with drivers and vehicles indistinguishably as a single entity, in this work vehicles are merely moveable objects whereas the driving role is played by an agent fully endowed with different cognitive abilities situated in the environment. We start by discussing on the role of the environment dynamics in supporting a truly emergent behaviour of the system, and then on an extension of the traditional car-following and lane-change models with the concept of situated agents. A physical communication model is proposed to explore the different perception abilities of each single driver agent as the basis for different interactions and overall system behaviour. Some performance issues are also identified and the result is a more flexible structure that allows for a more realistic representation of drivers' behaviour in microscopic simulation models.

Categories and Subject Descriptors
D.2.1 [**Software Engineering**]: Requirements/Specifications – *methodologies (agent-oriented)*

I.2.11 [**Distributed Artificial Intelligence**]: i*ntelligent agents, multi-agent systems.*

General Terms
Algorithms, Design, Human Factors.

Keywords
Situated Agents, Agent-based Traffic Simulation, Microscopic Modelling and Simulation, Car-Following, Lane-Changing

1. INTRODUCTION
The issues concerning traffic and transportation in urban scenarios are so evident that regular users have already realised that most infrastructures are working near their saturation condition mostly due to the more than ever increasing demand. This inevitably implies considerable economic, social, and environmental losses that must be minimised somehow. Some attempts to cope with the potential limitation of road capacity have been put into practice, such as physical modifications to the infrastructure and the improvement of control systems. The former is no longer the best alternative to tackle such a problem. Besides the high cost of implementation, it causes disruptions and damages the environment. In the latter situation, some good advances and successful experiences have contributed to the reduction of problems related to traffic jams. Despite the relatively good improvements they are able to produce, they cannot be considered a lasting solution either. Therefore, current research still seeks alternative means to cope with the traffic and transportation domains.

Using simulation is imperative in planning and realising the correct relation among the parameters of the domain. However, most analyses are carried out on an individual basis as an attempt to reduce the number of variables observed and to simplify the process of finding out their correlations. This brings about the issue of how different standpoints from which the domain is viewed could be coupled in the same model and simulation environment in order to allow for wider analysis perspectives [1][9][16]. This is not a recent concern, though. The basic general framework for a fully transportation theory identifies two different concepts, borrowed from Economics, which encompass all aspects related to demand formulation and supply dynamics within the framework, including multi-modal selection and activities planning [11].

Arguably, realistic models are the first instrument to allow the integration of different analysis perspectives in virtually any application domain. However, modelling is not an easy task and abstraction is often necessary in order to make thinks feasible. The autonomous agent metaphor has been increasingly used in this way and offers a great deal of abstraction while important cognitive and behavioural characteristics of the system entities are preserved. Also, advances in engineering environments for multi-agent systems have fostered the idea of overall system behaviour that emerges from the interaction of microscopically modelled entities.

In this paper we bring this discussion forward and ascribe to the environment the responsibility for coping with the complexity inherent in the transportation domain, more specifically in the field of traffic modelling and simulation, in order to provide engineers and practitioners with an adequate framework for integrated analyses. Complexity is expected to emerge from the interaction of simpler self-cantered autonomous entities in pursuit of maximizing some individual or collective utility measure. We start by discussing on some potential applications of the concepts of agents and multi-agent systems to such a complex domain, in section 2, and try to bring about the importance of the environment abstraction to agent-based simulation in section 3. A detailed explanation on the interaction mechanism used to support the implementation of situated agents is presented in section 4. In section 5 we conceive the architecture of a system to support practical simulation of traffic scenarios on the basis of the concepts discussed, which is followed by some interaction examples to illustrate the approach proposed, in section 6. Some conclusions are drawn and presented with important considerations for future developments.

2. MAS-T: MULTI-AGENT SYSTEMS APPLIED TO TRANSPORTATION

The abstraction approach of MAS consists of representing a system by multiple entities that exist in a common environment and interact in order to achieve specific goals. These entities that are coined agents, exhibit intelligence, autonomy and some social ability. Some examples of applied MAS in the field of traffic and transportation engineering can be found in the literature [2][5][13]. However, most of the applications are concerned with the control system, even though it is possible to recognise an increasing interest in the driver element. The assumption in the former examples relies on the representation of adaptable control system as a community of controller agents, which co-operate in order to achieve an optimum plan to meet the variable demand [14]. In these cases the movement is represented on the basis of simplified models that, in the great majority, adopt a simple approach of using a reactive structure. Other models where communication mechanisms and drivers with mental attitudes are of importance are found in [3][15][17].

Transportation Engineering is definitely a very broad field of knowledge and contemporarily has evolved so quickly as Intelligent Transportation Systems (ITS) start to make part of everyone's daily life. According to [4], the underlying concept of ITS is to ensure productivity and efficiency by making better use of existing transportation infrastructures.

From what has been discussed above it is reasonable to see this domain as formed of heterogeneous entities, which are geographically and functionally distributed throughout the environment. They pursue individual or collective goals, interact with one another and may transform the environment as well. From observation it is possible to realise three main components in our application domain, namely the moving element, the control system and the road network.

In very basic terms, the moving element is the vehicle that moves from one point to another throughout the network. Disregarding the importance of pedestrians in this first stage of this work, we consider bicycles, motorcycles, automobiles, trucks and buses as examples of moving elements. However, they are actually moving objects steered by their drivers and sometimes occupied by many other passengers that are people with a trip purpose. Also, their decision concerning how the trip will be carried out in most cases seeks to minimize some individual sense of cost. Therefore, we make a clear distinction between travellers and vehicles.

From a transport planning perspective, the inhabitants of urban areas are potential travellers with specific trip needs. Prior to each journey, travellers must make some options basically regarding mode of transport (whether to drive their own cars or to take a public transport service, for instance), the itinerary and a departure time. To the contrary, in the traffic system perspective flow is actually formed of each single vehicle. Nonetheless, vehicles moving throughout the network are steered by their drivers and hence drivers and vehicles are dealt with indistinguishably in virtually the totality of microscopic models [7][8][10]. In the microscopic point of view, it is the driver behaviour that influences traffic flow. Actually drivers manifest an interesting yet implicit social interaction – they compete for the limited resources of the network infrastructure. These different interactions may emerge on an aggregate perspective as these properties will become available in terms of natural stimuli to the inhabitants, who will behave accordingly as they have different perception capabilities and different goals.

3. THE ENVIRONMENT ABSTRACTION

The perspective over **environments** for MAS has been changing in the direction of an increasing importance of this entity. Danny Weyns and colleagues [19] stress out the importance of considering the environment as a first-order abstraction in the engineering processes of developing MAS. Weyns recalls a classical definition of **autonomous agent**: "a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future" [6]. From this definition he states "the importance of the environment as the medium for an agent to live, or the first entity the agent interacts with" [20]. He also recalls the notion of embodiment as "the fact that an autonomous agent has a "body" that delineates it from the environment in which the agent is situated".

Let us take a better look at the definitions above (of autonomous agent and of embodiment). The first states that the agent is not only situated in the environment: it is a component part of that environment. While not contradicting, this is diverse from the second definition which presents the agent and the environment as separate (and separable) entities. We could redefine an agent's body as a subset of the environment. This allows us to clearly define the agent (the agent still has a body) while providing a wider and more complex notion of environment. We will refer as the agent's body as the agent's internal environment. The environment without the agent's body is the agent's external environment.

In [12], authors differentiate a *physical environment* and a *communication environment*. The physical environment models the physical existence of objects and agents, whereas the communication environment includes the structures that support exchange of information (knowledge). These include roles, groups and communication protocols. They further define *social environment* as a restriction to the set of communication environments. A social environment is "*a communication environment in which the agents interact in a coordinated manner*". Note how the definition somehow restricts the forms of communication that may occur in a MAS. Tummolini and colleagues [18] introduce *Behavioural Implicit Communication*, in which case communication clearly occurs at the physical level (via perception), diverging from Odell's definition [12].

Both views can be unified by extending communication to the *physical environment*. We then classify communication into two main modes: *implicit communication*, occurring in the physical environment and *explicit communication*, occurring in the communication environment and regulated by high-level protocols (out of the scope for this paper). We further classify implicit communication into two distinct forms: *physical communication* (related to the observability of objects and agents) and *behavioural communication* (related to the observability of agent's actions). For the rest of this paper, we will focus on the implicit forms (physical and behavioural).

Physical communication occurs when an agent produces influences over its external environment, these influences produce a state change in that environment, that state change is perceived and interpreted by another agent (could be more than one), and this agent possibly changes his own behaviour in face of the interpretation. As an example of physical communication, consider the following scenario. When a driver wishes to communicate a lane change to the neighbouring agents, it switches the appropriate car light on. This implies **producing an influence** that will most likely result in a **state change** of the vehicle object controlled by the driver. This change will be detected by the agents that "*pursuing their own agenda*", are scanning the environment for visual perception. Some of the agents will **interpret** the state change as an intention of the peer driver and possibly change their own behaviour in face of the peer's intentions.

Behavioral communication works the same way around, with the difference that it occurs when an agent produces influences over its own internal environment. Examples would be a semaphore controller agent switching the signals, or a flagman waving his arms. The action consists of a list of influences over the agent's own body (the *internal environment*), although success or failure may still depend on the *external environment* (i.e., a power failure would prevent the semaphore controller from switching the lights). This is a very important feature of the model. An agent does not fully control its *internal environment*, since it is also a part of the coexisting agent's *external environment*, and so the agent may be "forced" by these external actions, at least up to some extent. Finally, an action may influence both the internal and external environments at the same time. This is transparent in our model, since both forms of communication are leveled by the way agents send their influences and receive the "messages" (via perception).

With these notions of environment and communication in mind, we will elaborate a definition of *physical environment* that stresses on the fact that an agent (and all other agents and objects) is *part of* the environment, instead of being merely inserted in it. We define it as collection of entities and laws. Entities may be objects (inanimate, yet possibly reacting or interactable) and agents (animate and partially *autonomous*). These entities and their interactions are ruled by a set of laws about their own properties and about the environment. All these collections are dynamic (objects may be created, consumed, transformed into other objects; agents may enter or leave the environment, "die" or be "born"). As a draft of a more formal approach we may say that

$$Env(t) = \{Objs(t), Ags(t), Laws(t)\}.$$

An object is characterized by:

- A set of *perceptible features* (*PF*), representing all possible features that may be perceived by agents. A feature may or not be active. We could identify the set of active features in a given time *t* as *PF(t)*. It should also be possible to provide the features with operational (run-time) parameters. As an example, consider the lights of a car. They are always perceptible but the current state of the light may change in each time step (it makes sense that a light is a feature that is always active but it may be "on" or "off" e.g., it is a run-time parameter of the feature).
- A set of *interactable features* (*IF*), representing interfaces that provide the environment access to modify the object state. Agents will not have direct access to the *IFs*. The set of active features in a given time *t* is *IF(t)*.
- A *set of properties* (*SP*), representing part of the internal state of the object. Note that we do not restrict the internal state to *SP*. Instead, we consider *SP* is part of the entities' internal state (which also includes the *PF* and *IF* sets).

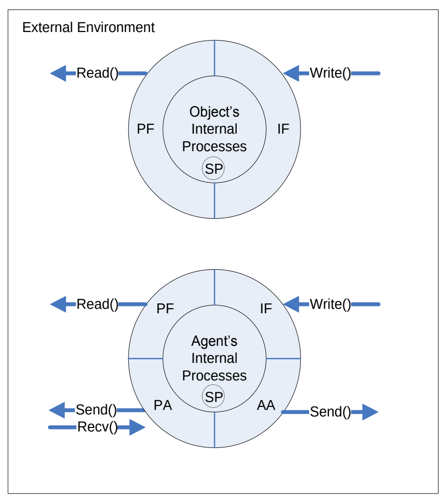

Figure 1 - Primary interfaces of objects and agents with the external environment

To limit the agents' autonomy, reflecting the fact that agents are conditioned by the environment of which they are a part of, and allow for *influences* of the environment over themselves, we define *agent* as a subclass of *object*. The agent may at best have partial control over these influences. This is fundamental to our approach. We long for a highly complete model to accommodate complex environments, allowing agents and agent's actions to be perceived by other agents (agents' actions also have perceptible features) and forced influences from the environment to be performed on the agents. Besides the inherited sets, an agent has:

- A set of *perception abilities* (*PA*), that the agent uses to send messages to the environment expressing the current *foci* of the preceptors and receive messages from the environment with perceptual representations (we will elaborate on this). For performance reasons, only one message is sent/received at each time step, possibly containing several foci/representations.

- A set of *action abilities* (*AA*), that the agent uses to send messages to the environment expressing influences over the agents internal and/or external environments (again, we will restrict agents to send only one message in each time step, though possibly expressing several influences).

Figure 1 illustrates how these sets provide the interface with the external environment of both agents and objects.

4. THE INTERACTION MECHANISM

To connect the basic concepts of our model, we illustrate the relations among the fundamental entities and roles in a class diagram where the roles are specified as “interfaces” (Figure 2).

The basic design of the suggested architecture is to consider that every entity in the traffic system is an object that influences the PF’s of agents (which are also objects). To achieve a desired perception of a part of the environment an agent becomes a listener by sending its *foci* to a mediator. All objects within the listener foci become its casters (becoming a caster of a listener means that the listener must perceive the casters’ PF). The mediator is responsible for translating the casters’ PF according to the current state and laws that rules the world and sending the set of perceptions to the listener accordingly. The interpretation of the set of PF’s received by each listener are stored or updated in the knowledge base of the respective agent. We name this type of knowledge as the agent cognitive map. Anticipating performance issues, and relating model elements to real world counterparts, we consider that the traffic environment can be divided into zones, each of which will be assigned a mediator. More on this topic will be discussed later on in this paper.

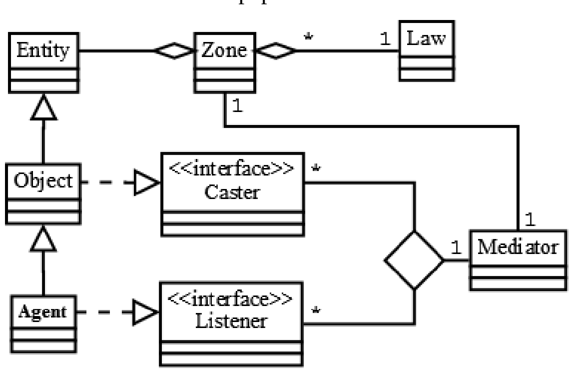

Figure 2 - Class diagram with the fundamental entities and roles

Thus, each mediator contains a representation of all entities inside its zone. So a listener sends its influence (for example a car that accelerates influences the external environment) and its foci to the mediator that updates its zone representation. The mediator contains a representation of every agent structure, allowing the correct interpretation of the agent’s set of PF and all its internal states, and updates the necessary information into that structure based on the influence sent by the listener. The influence created by an agent affects the entire surrounding environment and consequently the perception of it. The mediator is also responsible for finding the correct casters for each listener based on the foci sent by each agent in every time step. All objects inside a given foci become casters to that listener. These casters are basically the entities that exist in the mediator, representing agents or objects in its environment zone that are inside the agent *foci*.

The mediator is able to read and write the state of any object including access to the objects’ PF’s (for example, if an agent is a car and it decides to turn on the lights it will change the characteristics of the front vehicles because they become more illuminated, so a perception feature (illumination) was changed in those vehicles because of an influence made by the listener. Therefore the mediator needs to access those objects internal perception future set, search for the illumination perception future in it and change it to a new value accordingly). If necessary, then the mediator alters the perception features of the casters based on the influence provoked by the listener and after it reads all of the casters perceptions features. With this information it builds the perception of the listener having into account the laws of the environment (for example, if a listener is looking at its front and has a truck and a car as its casters, if the caster car is in front of the truck and the listener car is very near to the truck the listener car cannot receive perception of the caster car, unless the law of the environment rules that trucks are transparent).

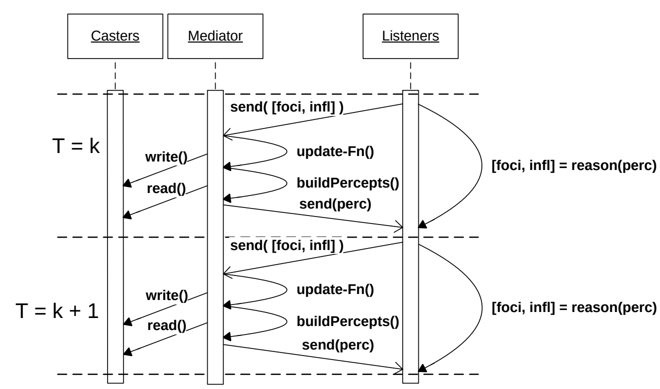

Figure 3 - Sequence diagram, detailing the interactions

With this perceptions received the listener must update its cognitive map. A cognitive map can be understood as a human driver mental perception of the objects surrounding its vehicle (other cars, traffic signs, traffic lights, people, buildings, and so on). An agent cognitive map is dynamically updated according to the perceptual representations received by its PA and by the execution of AA. After finishing updating the cognitive map a time step cycle is terminated. When a new one begins each agent has to decide on the action (influence) it must take, and where to focus its attention. The decisions are made based on the information of the cognitive map updated on the last time step, and on its own desires (desired destiny, desired speed, desired sight, and so forth). Sometimes the information contained on the cognitive map is not enough for an agent to transform a desire into an intention causing the agent to engage in a course of actions (e.g., it desires a left lane change but the left back vehicle perception is too old to risk it without updating it first). In these cases, an agent can continue its movement and focus its attention to the desired scene in order to obtain the necessary information to fulfil its desires.

The model of the interaction mechanism explained is depicted in Figure 3, in form of a sequence diagram, and the concepts herein presented are illustrated in a more concrete way through an example scenario in section 6.

5. SYSTEM OVERVIEW

According to what has been discussed so far a distributed system is defined to support the implementation of a microscopic simulation engine (MSE). The MSE contains all the world states and objects, and the laws of the world. It also contains the mediators that will translate and send the updated perceptions of objects to the agents that need them. The necessity of a distributed system is a must to guarantee system efficiency and also as a natural way to implement the entities of our application domain.

Basically the world is represented by a set of zones each containing a mediator. Each zone runs independently, having a centralised process that is responsible for the coordination of the world time steps (it guarantees that every zone processes the correct time step, meaning that it is not possible to have different zones processing simultaneously at different time steps). This synchronous process is also responsible for reading the topology of the networks, dividing them into zones, receiving the registration of mediators, and assigning them an appropriate zone. A simulation cannot be started until each zone has been assigned a mediator. It also allows registration of graphical interface modules providing them, in the registration, with the address of each mediator. Such a structure also allows for the simulation to run with no graphical support, which can contribute to speed up simulation studies.

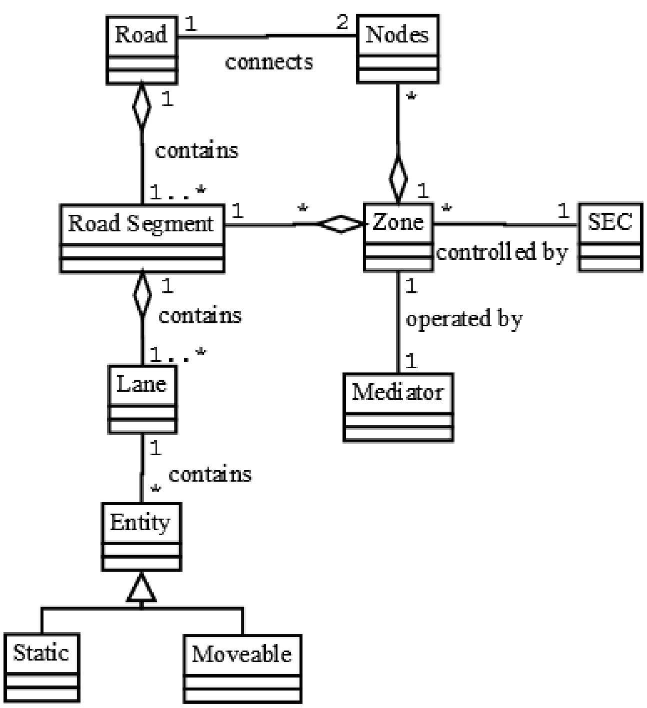

Figure 4 - Class Diagram of the environment domain

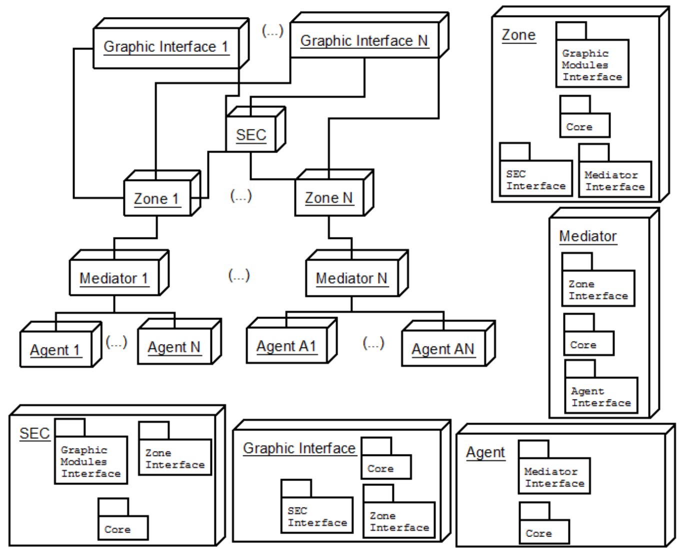

Figure 5 - System Physical Overview

Each mediator provides a communication interface responsible for sending the updated zone states to the different graphical interface modules so they can create real-time graphical representations of the simulation in runtime. There is also a centralised process that provides a communication interface for these graphical modules in order to allow them to stop or to start simulation runs, change environment characteristics such as the set of laws, load different networks, save simulation states, and so on. Such a centralised process is named SEC (**S**imulation **E**ngine **C**ontroller).

In Figure 4, it is possible to identify the domain entities, as well as their relations. A connection between two nodes represents a road. A road is a set of road segments. The division of a road into road segments depends on the different number of lanes or the different geometry a road can have. For example, if in the beginning of a road there are two lanes, but in the middle of the road it passes to have only one lane, it means that the road has two road segments – a road segment with two lanes and another road segment with just one lane. The world objects are decomposed into two different entities, namely the entities that have the capacity to move (vehicles and people, for instance) and the ones that are static (traffic controllers, road signs – both horizontal and vertical, road obstacles, and so on). In every given time an entity is situated in a lane.

A system physical overview is represented in Figure 5. In that structure a mediator has always the necessary information to construct perceptions for the correct behaviours of the world agents. Their interaction will follow the mechanism proposed in this research.

5.1 Environment Zones

Since the perception treatment and communication can be a heavy load for overcrowded networks the distribution of the environment perceptions becomes critical in order to improve the global efficiency of the simulation.

In order to assure that each agent receives the world perception efficiently in every time step, we assume that the process that delivers it has a limited capacity of the number of agents it has to inform. So a distributed division of the environment is a question of defining the correct capacity limit and number of perceptions a mediator will be dealing with. Such an organisation easily resembles the concept of traffic zones, used in control and management systems in most urban areas.

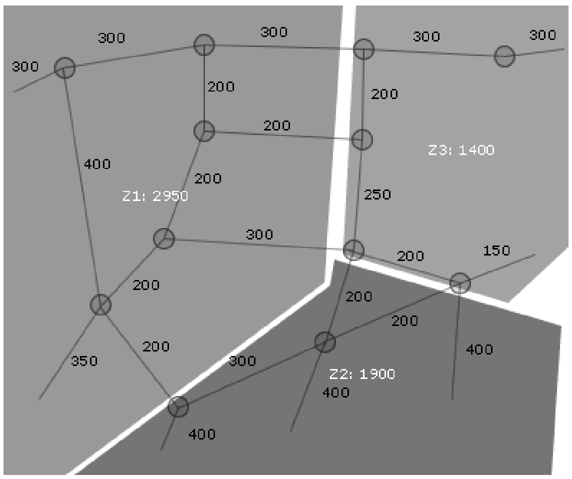

Figure 6 - Example of a possible network

As defined before, the entities responsible for the delivery of the perceptions are the *Mediators*. Analyzing the scenario presented in Figure 6 and assuming that M1 has a limit capacity of 3000 vehicles, M2 of 2000 vehicles and M3 of 1500 (the limit capacity of Mediators is calculated based on the processing capacity of the machine in which they are instantiated). The division into different Mediator zones is easy to obtain. Each link (Road Segment) has a physical capacity, limiting the quantity of vehicles it can contain. This means that in the worst scenario each road segment will only ensure that number of vehicles. So a mediator zone is defined as a set of road segments, whose sum of their capacities is equal or lower to the limited vehicle capacity of its mediator.

This way it is possible to guarantee that the mediator will process, in the worst scenario, the world perceptions of a number of drivers equal or lower to its own capacity. Translating it to the scenario of Figure 6, M1 will be assigned zone 1 (Z1 in the figure), M2 will be assigned Z2 and M3 will be assigned Z3. This means that each of the Mediators will be responsible for translating the zone objects' perceptible features to all agents inside its assigned zone that ask for it.

6. EXAMPLE SCENARIO

Consider the following scenario as depicted in Figure 7, representing the current state of the environment and already populated with all the casters and listeners that will interact throughout the example. The visual focus (for the current time step) of the agents controlling vehicles A, B, C and D is represented by the highlighted circle slices. In fact we opted to represent all of these vehicles to explain different situations that occur in traffic simulations and also to explain the concepts related to the "car following" (CF) and "lane changing" (LC) behaviours. Let us call the agents by the letters on the vehicles. Along with their foci, they have also expressed the influences over the environment for this time step.

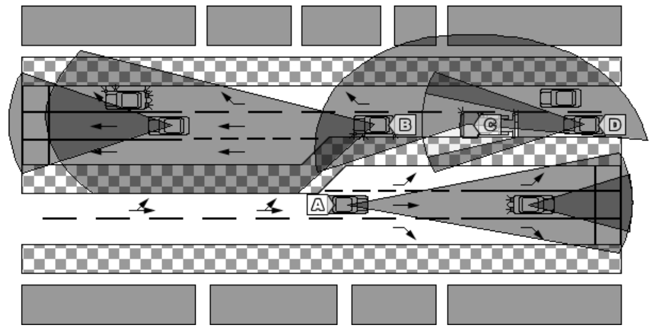

Figure 7 - An example of a time-step of the simulation

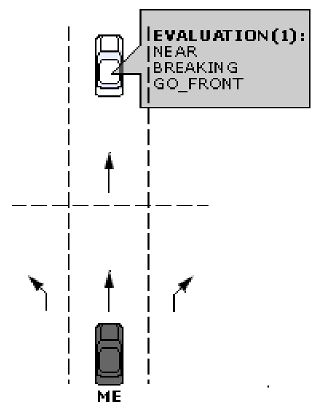

Figure 8 - Cognitive map of agent A

To ease the understanding of the concept of CF let us centre on agent A. Since it wants to go in front, its foci are naturally the front area. Take into account that as it becomes a listener the front vehicle becomes its caster. In the meantime the cognitive map of the agent (see Figure 8) is updated according to the interpretation of the received PF's (given by the Mediator). This information is given with regard to the object which is being observed by the subject driver, so perceptions are enclosed into balloons attached to the object being observed.

For this specific example agent A will take the particular action of "BRAKING". That's because it does not have any previous deduction (previous time step) of the other vehicle's velocity ("REALLY FASTER"; "FASTER"; "SLOWER" and "REALLY SLOWER"). In the next time step it will send that action to its mediator.

More complex situations can occur, like demonstrated by agents B and C. Agent B was having the same attitude as the one demonstrated before but new variables will make it to change (see Figure 9). Assuming that it wants to go in front, a new lane appears in that direction and the front vehicle was evaluated as going "SLOWER". It will take the action "CHANGE_TO_LEFT_LANE" then. This kind of actions transpires when an agent wants to maintain or achieve its desired velocity and is inherited from the lane changing concept.

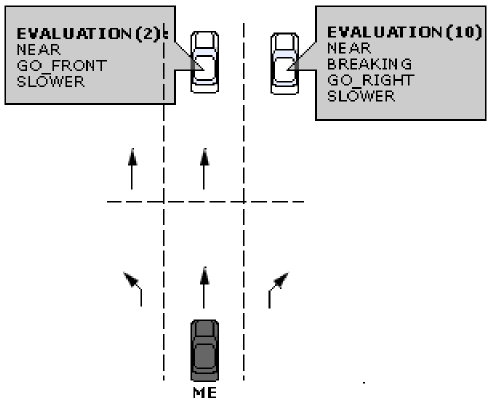

Figure 9 - Cognitive map of agent B

The previous figure also illustrates a representation of a "front right vehicle" that is having the intension of turning right. If in the next time step it transforms its intention into an influence, it will be deleted from agent B cognitive map.

At the same time agent C is in a delicate situation. It needs to go to the right lane to accomplish its path direction previously defined (supposing). Like in real situations, in which we need to look into the mirrors and take care with the front vehicle, it sets its foci to the front, back and right sides. The Mediator informs it about all the casters positions, velocities, acceleration and intentions (PF's) and the evaluation of its cognitive map will be like the one represented in Figure 10. The fact that the back right vehicle is being faster than itself will not permit the lane changing in the current time step (according to its own AA's) forcing it to wait for the next time step. If in future steps the back right vehicle does not pass him or new similar situations occur it will be impossible to make that action and agent C will be forced to stop.

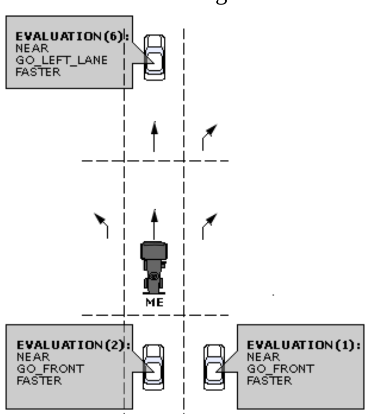

Figure 10 - Cognitive map of agent C

Taking into account that in human behaviours there is also a factor of cordial attitudes, it is agreeable to think that agent C can try to change to another lane to let pass the back vehicle (since its velocity evaluation is "FASTER"). This kind of actions is also inherited from the lane changing concept.

The representation of agent D intends to illustrate two different kinds of laws in the present scenario (transparent and opaque objects). The PA's are affected by this laws since the Mediator interprets the PF´s according to them and to the agent' foci. As a consequence the casters are not the same in the two different configurations. In the case of agent D there are two vehicles directly in front of it and inside its foci (C and B). If the laws of the environment are configured to opaque objects then the mediator won't give D the PF's of object B (vehicle C is a truck and blocks the visibility of agent D). Otherwise if the laws are configure to allow transparent objects then both C and B PF's will be included in the information that the mediator will send to agent D. This example shows the influence that the laws of the environment can have in the capture of perception of each agent.

In Figure 8, Figure 9 and Figure 10 notice the numbers that appear inside the parentheses and after the evaluation word. Those numbers represent the last time that the evaluation of that caster was done. That means those agents have more or less trust on their evaluations according to their PA's (for instance, if a back car is FAR and SLOWER the agent does not need to verify whether it is near every time step). It is possible to have a factor in each agent that dictates how each agent will trust on predicting future positions of its surrounding objects. For example, consider that an agent looks back in time step n and gets the perception of an agent called X. If in the time step n+20 the agent needs the information about agent X to perform an influence, it must decide whether to have to look back to update X perception on its cognitive map or if it trusts its future prediction on information perceived 30 time steps ago.

A prototype of the proposed system is being developed and some basic features of the communication mechanism were implemented, demonstrating the potential of this approach in extending traditional car-following and lane-changing behaviours. The environment is a first-order abstraction that plays an imperative role in this framework being developed. An example of its interface is depicted in Figure 11.

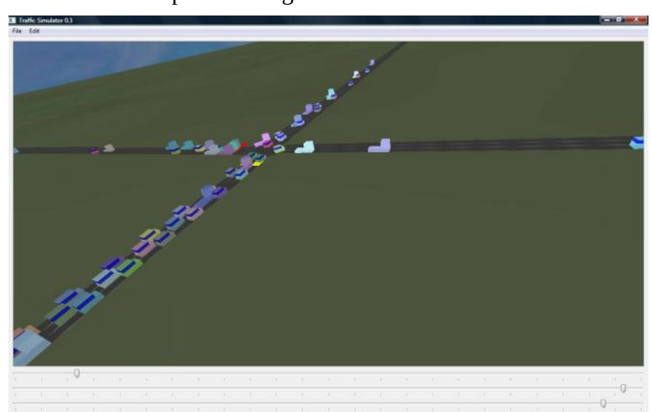

Figure 11 – Prototype of the simulation environment

7. CONCLUSIONS

In this work we propose a multi-agent model to cope with the complexity inherent in microscopic traffic simulation modelling in order to provide engineers and practitioners with an adequate framework for integrated analyses. The physical conceptualization of the environment using the interaction mechanisms presented as the basis for every interaction among agents and the environment itself allows for different perception abilities of individuals to be implemented and assessed, which is expected to have a direct influence in the emergence of the system overall performance in different circumstances. Therefore, a truly agent-based microscopic simulation approach must necessarily be build on the basis of the concept of situated agents and consider the environment as a first-order abstraction, playing as relevant roles as other entities in the system. In this way, as drivers are integrant parts of the environment and interact directly with it, more realistic behaviours can now be considered. With such a concept of environment, traditional car-following and lane-changing models can be extended to feature more contemporary performance measures, which can include influence of road-side parking, collisions, interaction with traveller information systems, en-route decision-making, and many others. This is just possible as different perception abilities of drivers can now be considered in the way they interact with their environment. An initial prototype with very simple features of the presented model has been implemented, to demonstrate car-following and lane-changing behaviours. The very next steps in this research include the improvement of this prototype to fully demonstrate all the potential of the concept of situated agents and the role of the environment in implementing more realistic microscopic traffic simulations. Also in the agenda, we expect to devise an appropriate methodology for validating and calibrating such agent-based microscopic traffic models. Following this, some simulations and analyses of performance measures will be carried out as well.

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