A "CONTEXT EVALUATOR" MODEL FOR A MULTIMODAL USER INTERFACE IN DRIVING ACTIVITY

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Abstract: Focused on new HMI for vehicles, this paper explains the methodology followed by Tecnalia to provide an evaluation of the context, based on sensors data, in order to achieve the optimum usability and ubiquity levels at any given moment, and finally to optimize the driving task from the safety point of view. The paper is divided into three sections. Firstly, there is an introduction in which the main concepts, multimodality and Ambient intelligence, are explained (section 1), and this is followed by the two projects related to the work shown here (section 2). In section 3 we will go on to describe the methodology used to obtain an evaluation of the context, as is necessary for a car HMI with multimodal capabilities. Finally, a particular "Context evaluator" is displayed in order to illustrate the methodology and report the work carried out.

1 INTRODUCTION

In order to decrease the number of accidents together with sustainable aspects, MARTA project (here and after MARTA) kicked off in September 2007. MARTA, is an initiative coming from the Spanish automotive industry, leaded by Tier 1 Ficosa International and contributed by relevant partners such as SEAT Technical Centre and first telecommunications operator Telefónica. The project is supported by the Spanish Ministry of Science and Innovation through CENIT Program managed by the public organisation Centre for the Development and Industrial Technology (CDTI). MARTA is focused in the study of the scientific bases and technologies of transportation for the 21rst Century that will lead to an ITS (Intelligent Transportation System). In particular, the main objective of MARTA is vehicle-to-vehicle and vehicle-to-infrastructure communications, in order to develop new technological services and solutions to improve road mobility. These intelligent systems of the future will contribute to decrease the number of accidents, to assess drivers so as to reduce energy consumption and finally, to provide on-board services for better information and minimizing the traffic congestion.

SEAT Technical Centre has an important and participative role in MARTA, as vehicle integral development center of SEAT car manufacturer. This paper is referred to Tecnalia research specifically developed under SEAT Technical Centre HMI research activities inside MARTA in which Tecnalia is involved in close collaboration with Cidaut R&D Center and Rücker-Lypsa Engineering.

Developments in recent years in the field of electronics and applications in the automotive sector (today around a third of the overall cost of cars is due to electronics) have made it possible to integrate within vehicles new technologies such as mobile phones, global positioning (GPS) or driving assistive systems (ADAS), among others.

Thus, as new applications and functionalities are being added to cars, the number of devices is increasing, as is the quantity of information for the vehicle driver. Consequently, there is an increasing demand for more efficient control architectures and technologies, especially for managing the data provided to the driver by the HMI (Human Machine Interface) mainly in order to not disturb him from his main activity, driving, and to maintain and/or improve the safety for everybody involved: driver, car passengers and pedestrians.

Since so much information can have a strong negative influence if it is not correctly handled and displayed, particularly in terms of decreasing safety, Tecnalia has been working on a particular methodology and the corresponding "**Context Model**" solution, oriented to evaluating the context and then providing information to take decisions about "what data" to show, "where" (screens, head-

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up displays, speakers, haptic pedals, and so on), and "when", taking the following two essential concepts into account:

- **Multimodality:** Multimodality is regarded as the characteristic which allows for human-machine interaction on two levels: Firstly, users with different skills can inter-actuate with machines via adapted Input/Output devices. Furthermore, the output can be adapted to the user context for different environments, e.g. driving activity. Both of these extend and improve the HMI.
- **AmI:** AmI is the abbreviation for the concept of "Ambient Intelligence", the words chosen by ISTAG (Information Societies Technology Advisory Group) as a guiding vision to give an overall direction to Europe's Information Societies Technology program. AmI stresses the importance of social and human factors, and it is at the forefront of a process which introduces technology into people's lives in such a way that its introduction never feels like a conscious learning curve: no special interface is needed because human experience is already a rich 'manual' of ways of interfacing to changing systems and services.

So, focusing on vehicle driving and taking advantage of new technological solutions, e.g. voice recognition, head-up displays, touch screens, cameras, haptic pedals, and so on, Tecnalia proposes a methodology designed to provide an evaluation of the context based on several sensors data in order to obtain the best usability and ubiquity levels for each particular moment on every occasion and finally optimize the driving task, mainly from the safety point of view. Moreover, a particular model applied within a project is also explained.

2 BACKGROUND

With respect to all the above mentioned, Tecnalia is currently working on several projects to apply paradigms such as multimodality and AmI to car HMI and two of these are the following:

- **MIDAS** (Oct'08-Sep'11): "Multimodal Interfaces for Disabled and Ageing Society". MIDAS is an ITEA2 project aimed at improving the autonomy, independence, and self-esteem of elderly people and of people with various different kinds of disabilities (visual-audition-mobility handicaps) by introducing the most advanced technologies in their everyday life by means of simple, predictable and unobtrusive multimodal interfaces. MIDAS is focused on home and driving scenarios, representative of the indoor and outdoor environments and Tecnalia is involved in driving scenarios, mainly in the application of multimodality to car HMI with a view to simplifying the user interface.
- **MARTA** (Jul'07-Dec'10): "Automation and mobility for advanced transport networks". National project in Spain focused on mobility and transport systems and how to apply ICT technologies to the automotive sector. Tecnalia is involved in technical & functional specifications, system designs and developments related to HMI (Human Machine Interface) within the vehicle, taking multimodality concepts into account.

Based on the activities carried out and the developments obtained up to now within these projects, the following sections explain the context evaluation methodology used in both (section 3), and shows the specific "Context evaluator" module prepared for the MARTA project (section 4).

3 CONTEXT EVALUATION: METHODOLOGY

Driving activity is mainly a visual task but the integration of new devices, information and safety systems make it mandatory to have new modes to inter-actuate with the vehicle, without reducing safety levels of car occupants and indeed even improving it.

Therefore a combination of different modes (visual, haptic, voice,…) to access the information related to the driving task has a strong influence on driver alertness, and it appears to be very important for the vehicle to have enough knowledge about the current situation (Ambient) and to provide a model of the context which is capable of helping with decision taking about "what", "where" and "how" to show the information and command the vehicle (HMI).

From this point of view, Tecnalia applies a methodology based on four steps oriented to preparing a model capable of reporting on any given occasion summarised information to help with the taking of decisions related to the HMI:

- **Actor's Definition:** This first step is aimed at detecting the main entities to be considered within the final model, and reducing the real world to the most significant elements. In effect, this means a modelling process which aims at the best abstraction of a system capable of being as simple as possible but without forgetting the essential data.

- **Sensors Selection and Grouping:** Once the problem has been reduced to the main actors, data should be collected from all sensors or devices capable of reporting information in the overall system and related to each actor. This step is completed with a grouping process to define specific groups of sensors, each of which is related to a particular actor (one actor could have more than one group of associated sensors), but providing a well-structured part of the actor behaviour.
- **Machines States Design:** The third step of this methodology is to design a machine state for each group of sensors as previously defined. This involves defining the main important states which could be taken into account based on the different range of values provided by each sensor in each group of sensors.
- **Summarized States Definition:** Finally, a minimum software interface is defined in order to provide the current status of the context according to the particular resumed states coming from the combination of states for each group of sensors and taking each actor into account.

The next figure shows graphically the abstraction or modelling process explained above:

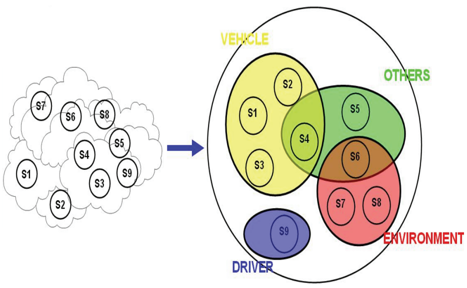

Figure 1: Modelling process.

The following section illustrates this methodology explaining the particular context evaluator designed within the MARTA project (the same methodology is being used in the MIDAS project).

4 MARTA "CONTEXT EVALUATOR"

4.1 Actors

Actors are the system reference points for assessing the current actual situation. So, taking the previously explained methodology into account, three different actors were considered to model the MARTA context: Driver, vehicle and environment:

- **Driver:** the person who handles the vehicle on the roads. This is the most unpredictable component inside a car; the system must be fully aware of the driver's condition.
- **Vehicle:** the artefacts that the people use to move from point A to point B.
- **Environment:** this entity includes all climatological conditions; in this case these will be reduced to three: rain, fog and daylight.

This group of three actors defines a three dimensions space (3D) due to the fact that each actor state is defined by only one group of sensors, and the corresponding machine state within the MARTA context evaluator. This means that the MARTA context model is fully defined by three coordinates reported according to each state for the three machine states corresponding to the three groups of sensors, each of which is linked to each of the above mentioned actors.

4.2 Sensors Grouping

Sensors are the group of devices which are able to provide basic information (car speed, acceleration etc.), both directly acquired from transducers or via communication protocols available in the system, e.g. typical CAN bus in vehicles.

Within the MARTA concept, the sensors collection is shown below ordered by actor:

Apart from these sensors, an additional sensor known as "ignition" is used to establish whether the vehicle engine is switched on or off for each actor.

All this information collected by means of these sensors enables us to prioritize any given message over another depending on the context or the driving situation for the car HMI (user interface) in the MARTA project. In this way the real world is reduced to three different groups of sensors, and the corresponding machines states, and all the different states for each group are explained in the next section.

4.3 Machine States

As has been mentioned before, each group of sensors has its own machine states representing the behaviour of the related actor. Therefore, the corresponding machines states designed for the MARTA project are shown the following three sub-sections for Driver, Vehicle and Environment.

Table 1: Sensors.

Actor	Sensor	Units	Meaning	
Driver	Drowsiness	on/off	OK	Driver state (fatigue)
			Fatigue	
Vehicle	Speed	Km/h	Stopped	Type of road derived from the car speed
			Urban road	
			Extra-Urban road	
			Rural road or highway	
	Angular Speed	m/s^2	Straight road or light curve	Type of road derived from the angular speed
			Hard curve	
Environment	Windscreen wipers	Gears (0-3)	No rain	Weather – Rain
			Light rain	
			Hard rain	
	Fog lamps	on/off	Good visibility	Visibility – (weather – fog)
			Fog	
	Car lights	on/off	Day	Visibility – (day/night)
			Night	

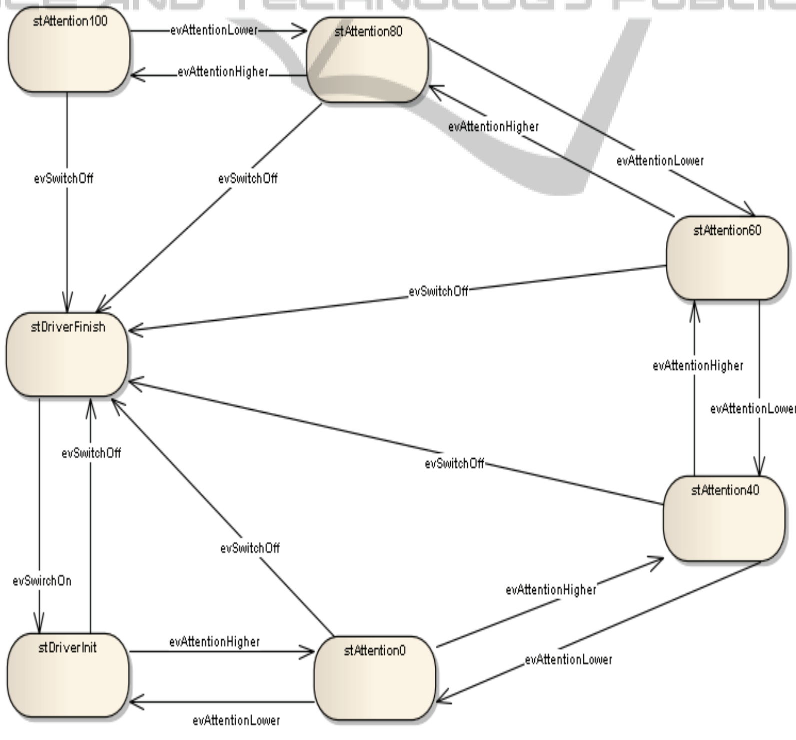

Figure 2: “Driver” Machine states.

4.3.1 Driver

The driver states are based on the drowsiness sensor, and taking into account the different levels and the information given by this sensor, the machine state for the MARTA context evaluator is as follows. As the sensor provided is able to detect four different levels, the following machine states have been designed taking seven different states into account:

The meaning of some of the “events” is explained in the following table:

Table 2: Driver - Events.

Driver		
Id	Events	Meaning
999	evSwitchOff	Ignition key turned to “Off”
210	evAttentionLower	Attention level has decreased
200	evAttentionHigher	Attention level has increased

The meaning of some of the “states” is explained in the following table:

Table 3: Driver - States.

Driver		
Id	States	Meaning
210	stDriverInit	Vehicle switched off
240	stAttention60	Driver with low level of drowsiness
260	stAttention100	Driver with optimal attention level

4.3.2 Vehicle

The vehicle states are mainly based on two sensors (speed and angular speed), and taking the information given by these sensors into account, the following machine state has been designed for the MARTA context evaluator:

The vehicle states take into account the speed and the angular speed sensors, and the combined information from these sensors generates the machine states shown in “Appendix” – figure 4.

The meaning of some of the “events” is explained in the following table:

Table 4: Vehicle - Events.

Vehicle		
Id	Events	Meaning
20	evSwitchOn	Ignition key turned to “On”
120	evSpeedG80	Vehicle overtakes 80 km/h
150	evYawRateH	Angular Speedy greater than 2,5 m/s^2

4.3.3 Environment

The “environment” machine states uses mainly the information given by four sensors (windscreen wipers, fog lamps and car lights).

The possible states are collected by three figures: the first one is the general one (see figure 3), and the next two correspond to the “night” and “day” concepts according to the car lights button position, meaning that if the car lights are switched on it is supposed that the environment light is not sufficient and the driver is driving at night. Otherwise the driver is driving during the day (see “Appendix” - figures 5 and 6).

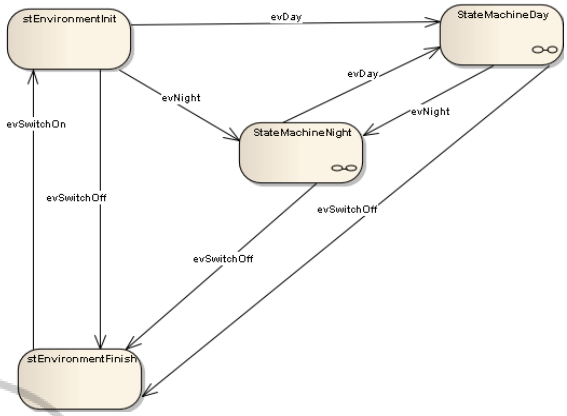

Figure 3: General part of “Environment” Machine states.

The meaning of some of the “states” is explained in the following table:

Table 5: Vehicle - States.

Vehicle		
Id	States	Meaning
110	stCarStopped	Vehicle switched “On”
160	stCarMovingG80	Vehicle moving speed (km/h)>80
150	stCarMovingG50Wavy	Vehicle moving 50<Speed (km/h)<=80 and hard curve

In the same way as for the “Driver” and “Vehicle” actors, the meaning of some of the “events” defined in the previously mentioned machines states for the “Environment” are explained in the following table:

Table 6: Environment - Events.

Environment		
Id	Events	Meaning
20	evSwitchOn	Ignition key turned to “On”
305	evNight	Car lights turned on (Night)
320	evRainLow	Windscreen wipers turned on with low speed
360	evNoFog	Fog lamps turned off (No Fog)

The meaning of some of the “states” is explained in the following table:

Table 7: Environment - States.

Environment		
Id	States	Meaning
310	stEnvironmentInit	Vehicle switched off
999	stEnvironmetFinish	Vehicle switched on
360	stInitNight	Start of the “Night”
375	stNightRainingLow	Night / Light Rain / No Fog
380	stNightRainingLowFoggy	Night / Light Rain / Fog

4.4 Interface

The interface of the MARTA "Context evaluator" system has the following methods to change the state of a sensor and to retrieve information from it:

- mGetContext(): return a vector of values that contains information about the actual state of the actors.
- mGetResumeContext(): return a context of the vehicle determined by an integer, where:

0–> ignition off, 1–>ignition on (car stopped), 2–> favourable, 3 –> risky, 4 –> critical;

- mReset(): assign the state Id="999" to all actors, resetting all machines states.
- mSetSensor(int IdSensor, int Level): assign a specific level (Level) to a sensor (IdSensor).

5 CONCLUSIONS

The main conclusions which could be mentioned related to this work, the concept of "Context evaluation", the necessity for new HMI for cars, and specially when it is applied the multimodality are the followings:

- Developments in recent years in the field of electronics and applications in the automotive sector have made it possible to integrate within vehicles new technologies (mobile phones, GPS or ADAS).
- The quantity of information for the vehicle driver is increasing due to new applications and functionalities are being added to cars.
- Much information can have a strong negative influence in terms of decreasing safety.
- Consequently, there is an increasing demand for more efficient control architectures and technologies, especially for managing the data provided to the driver by the HMI in order to not disturb him from driving.
- Tecnalia propose a particular methodology and the corresponding "**Context Model**" solution, oriented to evaluating the context and help on taking decisions about "what data" to show, "where", and "when", taking two essential concepts into account: Multimodality and Ambient Intelligence.
- Tecnalia "Context model" methodology is based on four steps oriented to preparing a model capable of reporting on any given occasion summarised information to help with the taking of decisions related to the vehicle HMI: Actors' definition, Sensors selection and grouping, Machine States design, and Summarized states definition.

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APPENDIX

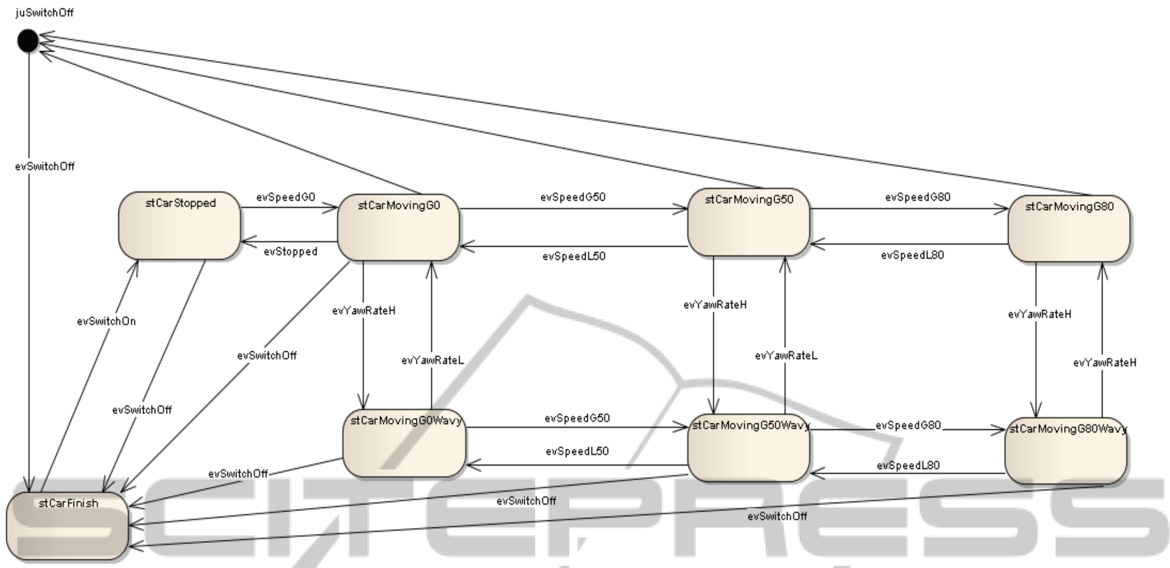

Figure 4: “Vehicle” Machine states.

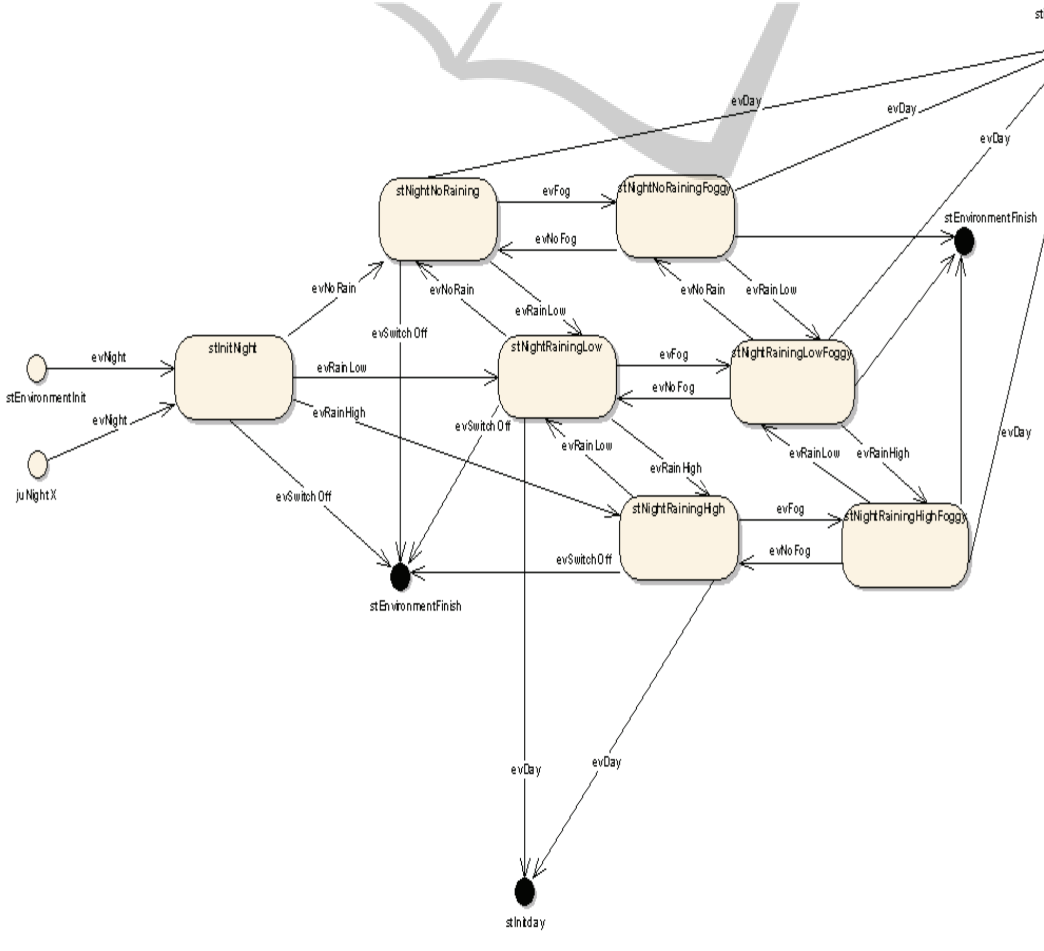

Figure 5: “Environment–Night” Machine states.

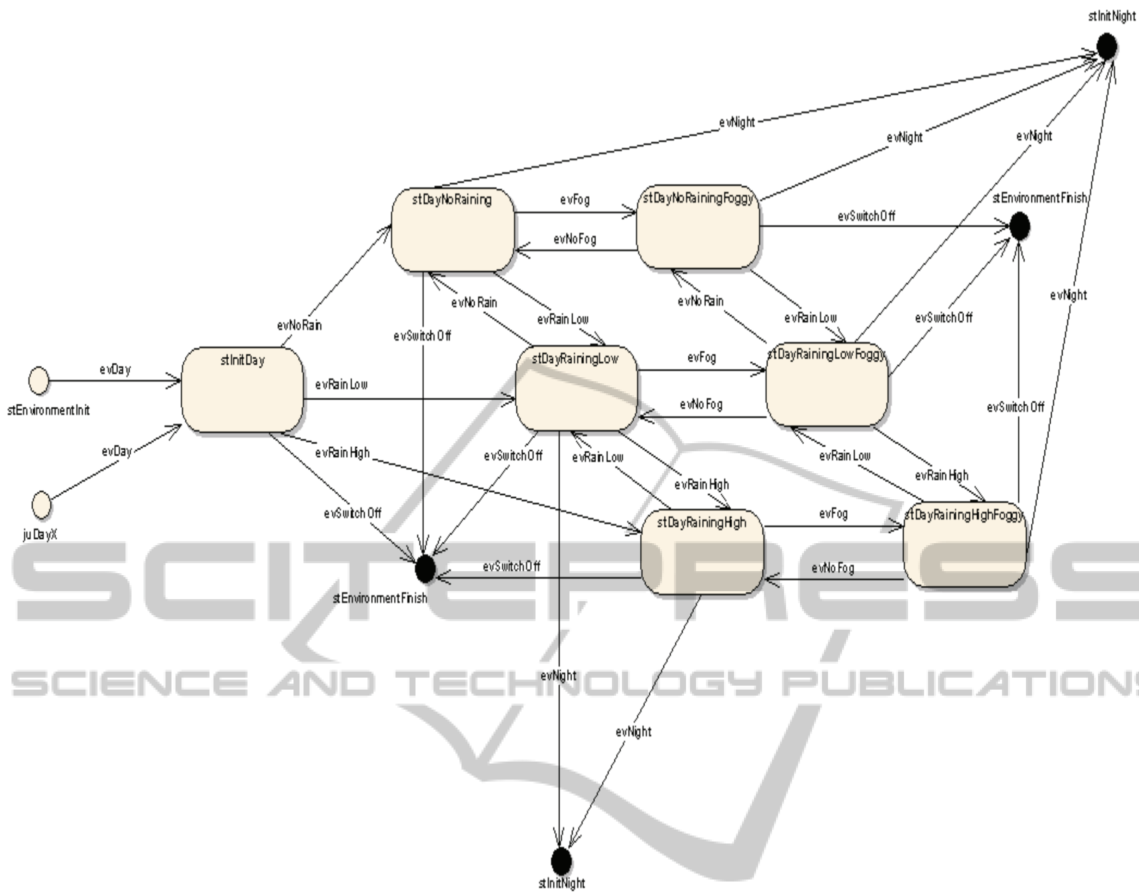

Figure 6: “Environment–Day” Machine states.