A Methodology for 3D Electronic Institutions

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ABSTRACT

In this paper we propose a methodology for the construction of 3D electronic institutions. 3D electronic institutions are normative environments where software and human agents can participate and collaborate in a joint 3D Virtual World. The proposed methodology covers the specification of the institutional rules, as well as the design and visualization of 3D environments for the specified institution. It is also supplied with a set of graphical tools that facilitate the development process on every level, from specification to deployment. The resulting system facilitates the direct integration of human users into Multi-Agent Systems as they participate by driving an avatar in the generated 3D environment.

Categories and Subject Descriptors

I.2 [**ARTIFICIAL INTELLIGENCE**]: Distributed Artificial Intelligence—*Multiagent systems*

General Terms

Keywords

Applications and Environments::Electronic markets and institutions, Tools and Techniques::Agent-oriented software engineering, including implementation languages and frameworks

1. INTRODUCTION

Nowadays there is a growing demand for applications which successfully integrate humans and computer programs. Such applications are a kind of open systems [5] and Multi Agent Systems (MAS) [6] view is perfectly suitable for them. However, the incorporation of humans into MAS has not been carefully studied. In general, the role of humans is limited to acting behind the scenes customizing agents' templates and letting the agents participate in the system on users' behalf. Although direct humans participation in MAS is highly desirable it is hard to implement using existing methodologies.

In order to address this shortcoming of MAS, we present in this paper a methodology for the construction of 3D Electronic Institutions, a concept that appeared from the combination of Electronic Institutions [4] and Virtual Worlds technologies. On the one hand, Electronic Institutions is a well-established MAS methodology that focuses on designing normative environments which establish what participating agents are permitted and forbidden to do. Unlike other formal methodologies, it is supplied with a set of tools that facilitate the whole development process from the specification of the institutional rules, to the deployment and execution of the institution. Although, Electronic Institutions do not prohibit human participation, no support is given to the development of interfaces or environments that facilitate their participation in the system.

On the other hand, Virtual Worlds are immersive environments that address the satisfaction of users. social needs and are complemented with a realistic experience. They are graphical environments, which imitate real world, simulating to a certain extent the way humans act and communicate in real life and offer an environment to "meet" people. Such interfaces go beyond the form-based approaches dominating the World Wide Web, graphically represent the user in terms of an avatar[1], literally putting users "in" the World Wide Web rather than "on" it. Although, social interactions is a main feature of Virtual Worlds, the mechanisms to control or structure such interaction are rather poor. Due to this fact the technology is used on a very limited set of domains. As the number of inhabitants of Virtual Worlds increases there is a growing demand for mechanism to structure and regulate participant interactions.

Neither Electronic Institutions alone nor Virtual Worlds alone permit the construction of complex applications composed by humans and computer programs. Hence, we advocate that these kind of systems can be constructed as 3D Electronic Institutions which combines the benefits of MAS and Virtual Worlds technologies. In the rest of the paper we present the steps of the 3D Electronic Institutions methodology and the deployment architecture.

2. METHODOLOGY

Applying 3D Electronic Institutions methodology requires 5 steps as shown in figure 1. This figure also presents the correct sequence in which the steps should be taken. Next, we detail on each of the steps.

[1]An electronic representation of one's self in a form of a graphical character.

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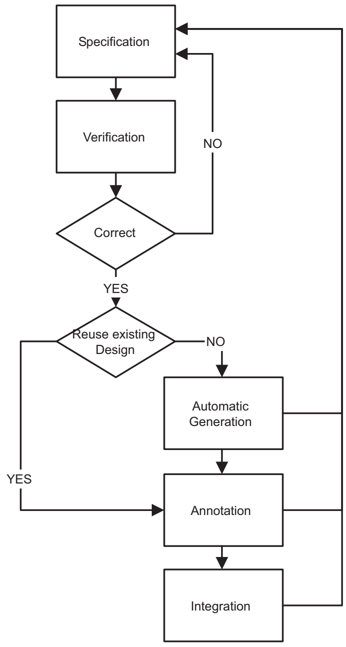

Figure 1: Methodology steps.

Specification.The specification step focuses on the definition of the institutional rules and it is the same as in the Electronic Institutions methodology [1]. It establishes the regulations that govern the behavior of participants. An institutions is specified by a dialogical framework, a performative structure and a set of norms. The *dialogical framework* establishes a common ontology and communication language, and the roles that participants can play. For each different activity, interactions among participants are articulated through group meetings, called scenes, which follow well-defined interaction protocols. The protocol of each scene, specified by a graph, determines the possible dialogues agents can have. More complex activities are specified by establishing relationships among scenes, in the so-called *performative structure*. The transit of participants between scenes is regulated by special (simple) scenes called transitions, which allow expressing synchronization, parallelization and choice points. The resulting network of scenes establish how agents can legally move among the different scenes depending on their role. Finally, *norms* capture the consequences of agent actions in the different scenes. These consequences are specified as obligations (commitments) that agents acquire while acting in the institution and have to fulfill later on. This process is supported by ISLANDER tool [1] which permits to specify most of the components graphically.

Verification. One of the advantages of the formal nature of the 3D Electronic Institutions methodology is that the specification produced on the previous step can be automatically verified for correctness by ISLANDER. The tool verifies the correctness of interaction protocols, the role flow among the different scenes and the correctness of norms. This verification starts with the validation of the correctness of the protocol defined by each scene. This includes checking that the graph is connected, that each state is reachable from the initial state and there is a path from each state to a final state, and the messages of the arcs are correct with respect to the Dialogical Framework. The Performative Structure establishes how the participants can legally move among different scenes. As we don't want them to get blocked in any scene or transition it is verified that from each scene and transition the users always have a path to follow, and that from any of them exists a path to the final scene that will allow them to leave the institution. Finally, ISLANDER checks that norms are correctly specified and that the participants can fulfill their commitments. As commitments are expressed as actions that users have to carry out in the future, it is verified that those actions can be performed.

If errors are found on the verification, the developers should go back to the previous step to correct them. If the specification contains no errors, there are two options. If the 3D Visualization of the environment is already created (reuse of the existing design) then the developers may skip the next step and continue with the annotation step. Otherwise, the generation step should be executed.

Generation. On the generation step the 3D Virtual World and its floor plan are created in a fully automatic way [2]. The institutional specification does not only define the rules of the interactions, but also helps to understand which visualization facilities are required for participants to operate in the institution. Some elements of the specification have conceptual similarities with building blocks in 3D Virtual Worlds, which makes it possible to create an automatic mapping between those. The scenes and transitions, for example, are transformed into 3D rooms, connections correspond to doors, and the number of participants allowed in a scene determines the size of a room. The generation can function in two different modes: Euclidean and non-Euclidean. In the first case the rooms on the generated floor plan are positioned so, that each two rooms where corresponding scenes and transition are connected in the performative structure graph by an arc are physically placed next to each other and there is a door between them. In the non-Euclidean case the rooms may be located anywhere and are not necessarily involved in any sort of spatial relationship. The movement between connected rooms in the non-Euclidean Virtual World is done using teleportation[2].

Annotation. On the annotation step we create a link between the concepts in the specification and the concepts of 3D Virtual Worlds and enrich this mapping with additional elements. The Annotation Editor tool is used to help the developer to do the annotation. It comes as a plug-in to ISLANDER and offers an additional view for scenes and transitions. This view displays the 3D representation of each scene and transition, where the incoming and outgoing arcs are visualized as doors. The doors can be moved along the walls but not eliminated. Each of the rooms is originally empty and in order to make the resulting 3D Virtual World more appealing, the Annotation Editor provides a set of standard objects and textures that can be used to enrich the design of the rooms. After this step the user can return to step 1, if for any reason he/she wants to modify the specification, or continue with step 5.

Integration. On the integration step the execution state

[2]the process of moving objects from one place to another instantaneously, without passing through the intervening space

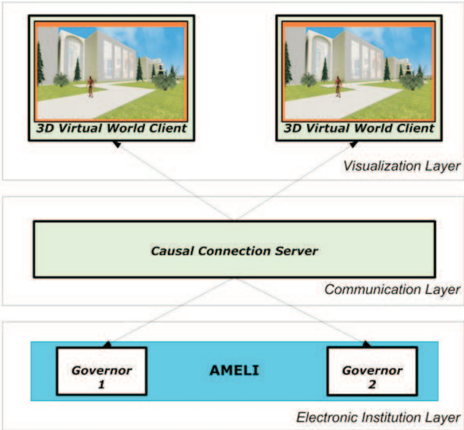

Figure 2: Runtime Architecture.

related components are specified. Agents participate in an Electronic Institution by exchanging messages with the institutional infrastructure. Hence, in order to connect the institution with Virtual Worlds, it is necessary to define a mapping between these messages and actions in Virtual Worlds. Actions are implemented as a set of scripts that modify the 3D Virtual World. Those scripts are executed as a result of receiving a corresponding message from the institutional infrastructure or as a result of an event generated directly by participants within a Virtual World. The scripts for the generic actions as entering scene, leaving scene, entering transition, leaving transition etc. are generated automatically. Next, the scripts that correspond to the specific messages that are defined in the ontology on the specification step must be created. If there is a need to map the data types in the ontology to 3D objects in the Virtual World it should also be done on this step. At the end, the correspondences between the messages and scripts (actions) are created by filling in the Action/Message table.

After accomplishing all these steps the 3D Electronic Institution is ready to be executed.

2.1 Deployment

For the deployment of the Virtual Worlds created following the 3D Electronic Institution methodology we use a 3-layered infrastructure (see Figure 2).

First layers is the *Electronic Institution Layer*. It uses the AMELI system [1] to regulate the interactions of participants by enforcing the institutional rules established on the specification step. AMELI keeps the execution state of the institution and uses it along with the specification to guarantee that participants' actions do not violate any of the institutional constraints. Agents in Electronic Institutions participate by exchanging text messages following a protocol predefined by AMELI.

Second layer is the *Communication Layer*. Its task is to causally connect the institutional infrastructure with the visualization system. At this aim it uses the Action-Message table created in the integration step. On the one hand, when an action from the Action-Message table is executed in the 3D Virtual World it sends the corresponding message to AMELI for verification. On the other hand, when it receives a message from AMELI, it updates the visualization by executing the corresponding action in the Action-Message table. In this way, the exchange of text messages with AMELI is transparent to human users, as they are generated as a result of their actions in the Virtual World.

Third layer is the *Visualization Layer*. It is used to visualize the 3D Virtual World. Currently, we are employing the Second Life[3] technology, which is one of the 3D Virtual Worlds available on the market, for this task.

The system allows for some of the participants (software agents) to be directly connected to AMELI, while others (human) participate by driving an avatar in the Virtual World.

3. CONCLUSION

In this paper we have presented the 3D Electronic Institutions methodology, which supports direct integration of humans into MAS-mediated environments. It is complemented with all the necessary technological support for the whole development process from specification to deployment. The methodology extends the Electronic Institutions methodology [1], to include specific requirements expressed by Virtual Worlds. We especially recommend using 3D Electronic Institutions for the development of applications that require human and agent involvement, high degree of structured interaction between participants and strict control over security issues. We want to remark that the methodology supports the efficient collaboration between humans and agents and facilitates the implicit training of the agents [3]. Physical separation of the runtime infrastructure into 3 conceptually different layers makes the system better portable, more scalable and easily changeable.

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