# v-mWater: a 3D Virtual Market for Water Rights[1] (Demonstration)

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## ABSTRACT

Most of MAS methodologies and infrastructures do not consider direct human participation even though humans can be seen as autonomous entities (i.e. human agents). Virtual Worlds (VW) provide all the necessary means for direct human inclusion into software systems. Virtual Institutions (VI) take advantage of this and combine Electronic Institutions (EI) and VWs to engineer MAS applications where humans participate together with software agents. In this demo, we introduce virtual mWater (*v-mWater*), a VI for water rights negotiation.

## 1. INTRODUCTION

Virtual institutions (VI) [1] offer interesting possibilities to both 3D virtual environments and MAS. First, thanks to the regulation imposed by an organization centred MAS –in our case an Electronic Institution (EI) [2]–, the 3D environment becomes a normative Virtual World (VW) where norms are enforced at runtime. Second, this 3D real-time system representation allows a human be aware of its system state and to directly participate in MAS by controlling her/his avatar in an immersive environment.

This demo illustrates a *v*irtual *m*arket based on trading *Water* (*v-mWater*) modelled as a VI with the aim of coordinating participants' interactions and supporting direct human participation in MAS. VIs provide a seamless interaction between both human and software agent participants. We present i) the specification of the system, ii) the VW generation from this specification, iii) the deployment using the Virtual Institution Execution Environment (VIXEE) and iv) how participants interact in the virtual environment.

*v-mWater* has been deployed using VIXEE, a robust Virtual Institution eXEcution Environment that provides interesting features, such as multi-verse communication and dynamic manipulation of the VW content. VIXEE is a generic and domain-independent solution. Its performance has been evaluated in high load scenarios (more than 500 agents).

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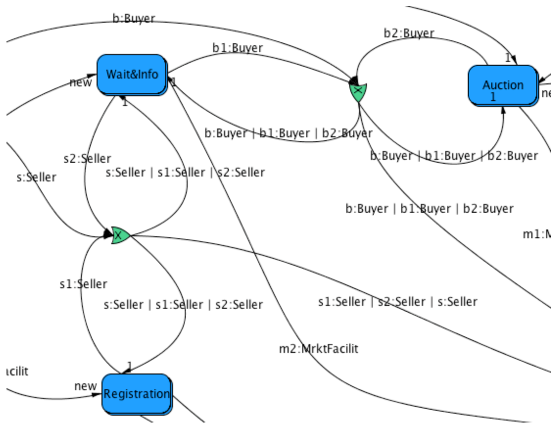


**Figure 1: Extract of v-mWater model specification**

VIXEE does not introduce any limitations on the scalability of the system as it maintains fast response times even in these scenarios [6]. Although *v-mWater* is an *e-Government* application, VI can also be used in other domains which may benefit from structured interactions and norm enforcement such as *e-Learning* and *e-Commerce*.

## 2. v-mWATER MODEL

The *v*irtual *m*arket based on trading *Water* (*v-mWater*) is a VI which models an electronic market of water rights. The market is a simplification of *mWater* [3] which is an Electronic Institution (EI) focusing on a water market and including conflict resolution features.

In *v-mWater* scenario, agents may adopt a number of roles. Irrigator agents can participate as either buyer or seller subroles while market facilitator and basin authority correspond to staff agents. Figure 1 shows an extract of the performative structure [2] (i. e. the work-flow among several agent activities called scenes in EI) of *v-mWater*. Besides the obligated initial and final activities to enter and exit the institution, it has three activities which enact the market: *Registration*, where the market facilitator is in charge of registering sellers' rights; *Waiting and Information*, where irrigators can ask for auctions' information to the market facilitator; and *Auction*, where the negotiation of water rights takes place. The auction protocol is multi-unit Japanese. We selected this protocol because it is suitable for perishable and divisible goods (in our case, water). Water rights are auctioned in consecutive rounds. There are three roles involved in this activity: buyers bid for water rights, the


**Figure 2: Initial aerial view of v-mWater**

market facilitator conducts the auction and the basin authority announces the resulting valid agreements.

## 3. v-mWATER DEPLOYMENT

In order to engineer *v-mWater*, we follow three steps. First, we specify the normative control layer of the VI – that is an EI– using ISLANDER tool [2]. The output is the EI specification introduced in section 2. Second, we automatically generate the 3D representation from this specification. Third, we define the mapping between VW actions and EI messages and vice versa. We have deployed *v-mWater* model using the *Virtual Institution eXEcution Environment* (VIXEE). Its architecture is composed of three layers: i) normative, ii) visual interaction and iii) causal connection.

The **normative** layer is composed by AMELI, the EI infrastructure that mediates agents' interactions while enforcing institutional rules [2]. AMELI can be regarded as domain-independent because it can interpret any institution specification generated by ISLANDER tool [2]. In our case, it interprets the specification defined in section 2. Software agents are directly connected to this layer. The **visual interaction** layer comprises several virtual worlds (VWs). Each VW can be implemented in a different programming language using a different graphics technology. VW clients provide the interface to human participants whereas servers communicate with the causal connection layer. The **causal connection** layer causally connects the visual interaction and the normative layers, i.e. whenever one of them changes, the other one changes in order to maintain a consistent state [4]. This layer implements a *multi-verse communication* mechanism that allows users from different VWs to participate in the same VI. The mapping between VW actions and AMELI protocol messages –and vice versa– is defined by a *movie script* mechanism. E. g., the welcome event to the institution has been mapped to a *"greeting"* gesture made by the *Institution Manager* avatar (see Figure 3). Moreover, VIXEE uses the Virtual World Grammar (VWG) concept and its implementation in the Virtual World Builder Toolkit (VWBT) to dynamically manipulate the 3D representation of all connected virtual worlds [5].

As a result of this engineering process, Figure 2 depicts the consequent generation[2] in *Open Simulator*, a multi-platform multi-user 3D VW server. In particular, it shows an aerial view of three rooms located at an open space that correspond to the three main activities in *v-mWater*. Software agents have been characterized as bots with the aim of enhancing their artificial nature: they are bold and have differentiated artificial skin colours that represent their roles (see Figures 3 and 4). Fig. 3 shows the login to the institution: the human participant sends a private message to the *Institution Manager* bot with the password and role (either seller or buyer). Fig. 4 illustrates how human participation in the auction has been improved by providing a comprehensive 3D environment. There, the market facilitator bot appears sited at a desktop and buyer participants at the chairs in front of it. This room includes dynamic information panels. Moreover, bots' bid actions can be also easily identified by human participants since they are displayed as raising hands.

[2]See http://youtu.be/hJzw40lQvUY for a complete visualisation


**Figure 3: Human avatar login: interaction with a software agent by means of a chat window**


**Figure 4: Bot bidding in a running auction**

## 4. CONCLUSIONS

This paper presents *v-mWater*, a Virtual Institution for the negotiation of water rights. We have proposed an immersive environment where human avatars interact with the environment and other participants in the system. As result, our system has favoured direct human participation in MAS. As ongoing work we are extending *v-mWater* with assistance services to participants in order to improve their participation in the system. Moreover, we plan to evaluate the usability of the prototype by measuring interface effectiveness, efficiency and user experience.

## 5. REFERENCES

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