Narrowing the Gap Between Humans and Agents in e-Commerce: 3D Electronic Institutions

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Abstract. Electronic Institution are regulated environments populated by autonomous software agents that perform tasks on behalf of users. Users, however, are reluctant in delegating full control of critical decisions to agents and prefer to make them on their own. In order to increase trust in agents we propose 3D Electronic Institutions as an environment inhabited by a heterogenous society of humans and agents. We present a novel approach that introduces humans to Electronic Institutions via 3D Virtual Worlds. Such a 3D Virtual World provides an immersive user interface that allows humans to observe the behavior of their agents as well as the intervention in the agents' decision process if necessary. We step beyond the agents view on Electronic Institutions, take a human-centered perspective and concentrate on the relation between humans and agents in the amalgamation of 3D Electronic Institutions.

1 Introduction

Nowadays individuals are the product of a particularly mobile and entrepreneurial society. As a result, individuals are socially constituted and socially situated in everyday business activities. Preece et al. criticize that the satisfaction of social needs, despite of its great importance, is widely neglected in nowadays systems [1]. A truly feasible e-Commerce system that supports business activities can hardly be obtained without taking care of the social issues behind these activities [2]. Most system analysts, however, perceive e-Commerce systems from a purely technical viewpoint without trying to establish the social and business norms that companies and consumers comply with.

Immersive environments such as 3D Virtual Worlds address the satisfaction of users' social needs and are complemented with a realistic experience. Virtual Worlds support to a certain extent the way humans act and communicate in real

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life and offer an environment to "meet" people. Such interfaces go beyond the form-based approaches dominating the World Wide Web and graphically represent the user in terms of an "avatar" [3]. Users are literally "in" the World Wide Web rather than "on" it. Overall, the design and development of Virtual Worlds has emerged as a phenomenon shaped by the home computer user rather than by research and development activities at universities or companies. As a result, Virtual Worlds are more or less unregulated environments. In order to exploit the benefits of Virtual Worlds interfacing e-Commerce systems, strong methodologies for reliable interactions need to be applied. Electronic Institutions, for instance, focus on controlling these aspects. In particular, an Electronic Institution is an environment populated by autonomous software agents that interact according to predefined conventions. Furthermore, Electronic Institutions guarantee that certain norms of behavior are enforced. This view permits that agents behave autonomously and make their decisions freely up to the limits imposed by the set of norms of the institution [4]. However, not much attention has been paid to the relationship between an autonomous agent and its principal. Users are rather reluctant in delegating full control of critical decisions to agents and prefer to make them on their own. A better modeling and, above all, understanding of this relationship is needed.

In this paper we present a novel approach that addresses this issue and introduces humans to Electronic Institutions (EI) via 3D Virtual Worlds. Such a 3D Virtual World provides an immersive user interface that allows humans to observe the behavior of their agents as well as the intervention in the agents' decision process if necessary. The major objective of this approach is to take a human-centered perspective on Electronic Institutions and concentrate on the relation between humans and agents in the new metaphor of *3D Electronic Institutions*. We expect that this new metaphor will reveal new insights about the relationship between humans and agents and, moreover, increase trust in agents inhabiting such e-Commerce environments.

This paper is structured as follows. In Section 2, applications of Multi-Agent Systems in e-Commerce are reviewed and related work in the area of human-computer interaction is presented. In Section 3, design considerations for 3D Electronic Institutions are outlined and the relation between humans and software agents in this environment is described. The architecture of 3D Electronic Institutions is presented in Section 4. Finally, a conclusion is given in Section 5.

2 Related Work

Multi-Agent Systems (MAS) have proven to be a perfect paradigm for modeling environments that are composed of many autonomous individuals. In order to develop complex MAS, sophisticated methodologies supporting the entire development life cycle including design, analysis and deployment are needed [5]. Methodologies that distinguish between the social (macro-level) and agent (micro-level) aspects of the system are preferable. However, considerable research efforts take an agent-centered view while ignoring social aspects of individual participants.

So, most research concentrates on the development of theories, languages and methodologies whereof Gaia [6], Madkit [7] and Electronic Institutions [8] are prominent representatives. Moreover, not much attention has been paid to applications of Multi-Agent Systems. One among the few is the recently completed MASFIT project [9]. MASFIT is a Multi-Agent Systems that enables participants to delegate the task of fish trading to autonomous agents. So, users are able to participate in multiple fish markets at the same time while ensuring traditional auctioning of goods. This project was designed as an EI and was deployed at the markets of Vilanova and Tarragona, Spain.

Another interesting application of Multi-Agent Systems is the air-traffic management system OASIS (Optimal Aircraft Sequencing using Intelligent Scheduling). OASIS combines artificial intelligence, software agents and conventional software [10]. Its purpose is to calculate estimated landing times, determine the sequence in which aircrafts are supposed to land and advise air traffic controllers on appropriate control actions. The system was successfully trialed at Sydney airport during the late nineties.

Social interaction plays an important role in real world commerce and are an important issue for the future of e-Commerce [1] as well. Some operators of e-Commerce Web sites even believe that online communities supporting social interactions serve the same purpose as the "sweet smell of baking cakes" does in a pastry shop. Both evoke images of comfort, warmth, happiness and probably even trust. An e-Commerce environment fostering social interactions was implemented by [11]. It incorporates a novel, spatially-organized and interactive site map that provides visibility of people, activities and mechanisms for social interactions. 3D Virtual Worlds implicitly address the issue of social interactions since location awareness, presence as well as direct communication are intrinsic elements. Inspired by the success of 3D graphical user interfaces in application domains such as computer games, CAD as well as medical and scientific visualization, researchers applied this emerging technology to new domains including e-Commerce. In [12] a 3D e-Commerce environment is proposed featuring animated products, which act as navigational aids, and guide users through the 3D representation of the online shop. 3D product visualizations literally "move around" and assist users in finding the appropriate section within the shop.

Another interesting representative, even though in the area of cultural heritage, is the reconstruction of Leonardo da Vinci's "Ideal City" [13]. Based on original sketches the city was realized as a 3D Virtual World. The main objective was to provide an immersive virtual experience of da Vinci's ideas and concepts and to offer users the possibility to explore the city in a collaborative fashion.

3 Design Considerations for 3D Electronic Institutions

The design of Virtual Worlds has been governed by different principles. Bricken identified in [14] the shift from the user role to a participant in the actual design, the move from interface towards inclusion (i.e. embedding participants in the design process within the environment), and the change from visual to multimodal interaction. It is argued that the design of Virtual Worlds changes from using familiar metaphors towards applying appearances that are completely arbitrary. However, in Virtual Worlds designs related to human everyday experiences have been predominant. The emphasis has been placed on the design of the *static* visual spaces. The development and research in distributed gaming environments as well as in computer-mediated collaborative design identified the need of dynamic generation of Virtual Worlds out of design specifications. For example, Smith et al. changed static 3D Virtual Worlds into adaptable worlds by incorporating agents as the basis for representing the world's elements [15]. The emphasis, however, was placed on the software side, i.e. the "society of agents" rather than on the *heterogenous society* of humans and agents. Contrary, we concentrate on this issue and describe main design considerations for 3D Electronic Institutions in order to address heterogenous societies.

Firstly, appropriate user interface design is crucial for sophisticated human-computer interaction, which especially applies to 3D Virtual Worlds, as such interfaces are designed with the goal in mind to emulate the way humans operate and interact in the real world. More precisely, 3D Virtual Worlds aim at combining the use of space with an immersive experience in order to construct a useable virtual representation of a particular domain. Space and objects in space are used to model different impressions. Social power, for instance, might be expressed in terms of "height". Proximity of things could indicate that they belong to the same group or are of a similar type. Humans live in a well structured environment following different metaphors. Metaphors such as buildings or streets might be used in Virtual Worlds as well [16]. Considering an Electronic Institution, a possible 3D visualization might be the metaphor of a town. Each building identifies an institution, different institutions are accessed via public transport and rooms refer to different activities that can be performed.

Virtual Worlds visualized in 3D are environments where people "meet". Such environments provide a consistent and immersive user interface that facilitates awareness of other participants. Communication and interaction between participants are main issues in these environments. Smith et al. point out in [15] that these environments have to provide appropriate mechanisms which enable users to communicate and encourage social interactions. Satisfying social needs of users is regarded a key issue in nowadays virtual communities but, however, remains mostly neglected [1]. 3D Virtual Worlds stimulate social interactions just by simple "visual presence" of other visitors. Being aware of other users constitutes an implicit and integral feature of this user interface and offers communication possibilities at any time detached from any physical place.

Another important issue in user interface design is the avoidance of overloaded interfaces. Traditional web pages overloaded with form elements such as input fields or checkboxes overwhelm and distract users. This issue is addressed in 3D Virtual Worlds by taking "distance" into account. More precisely, the detail level increases or decreases according to the avatar's distance to a particular object, i.e. the closer an avatar is to an object the more information is visible and presented to the user. This reduces the information overload known from conventional interfaces while still conveying a basic impression of the context.

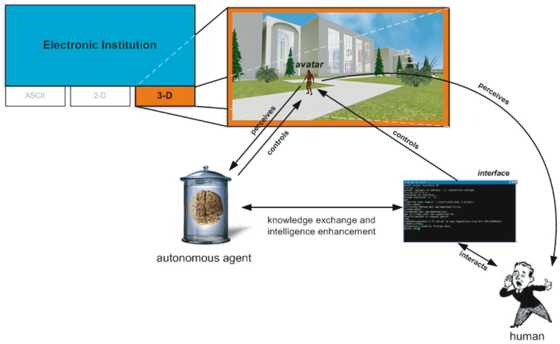

Fig. 1. Relation between agents and humans in 3D Electronic Institutions

Secondly, beside humans, other types of participants might be present in e-Commerce environments. Users delegate activities to autonomous (software) agents that act on their behalf in such environments. Our view on the relation between humans and software agents in 3D Electronic Institutions is illustrated in Figure 1. The couple agent/principal is represented in a Virtual World as an *avatar*. Either a human or an agent may control the avatar through the *interface*. Metaphorically speaking, the interface is a "glove puppet" that translates all actions of its "puppeteer" into an institutional and machine-understandable language. Agent and human cooperate during the accomplishment of tasks the human has to deal with. Representing autonomous agents as avatars allows humans to perceive agent's actions in a transparent way that assists in deciding whether the human should intervene or not. It is envisioned to provide additional interaction possibilities between humans and agents. Consider a human issuing instructions to an agent or an agent suggesting solutions to the human like an "expanded intelligence" mechanism similar to "expanded reality" offered by state-of-the-art virtual reality tools.

The duality, agent/principal, introduces the possibility of co-learning between humans and their agents. On the one hand, the agent learns to make proper decisions from its principal and on the other hand the agent assists the human in learning the rules that apply in the environment. Additionally, a human might be advised by its agents about the consequences of certain actions by compiling information gathered from external information sources. Behaviour patterns of other participants in specific situations might be observed in order to derive solutions for current tasks.

4 3D Electronic Institutions

3D Electronic Institutions combine the two metaphors of *Electronic Institutions* and *3D Virtual Worlds* while retaining the features and advantages of both. Originally, an Electronic Institution is an environment populated by autonomous software agents that interact according to predefined conventions on language and protocol. Furthermore, Electronic Institutions guarantee that certain norms

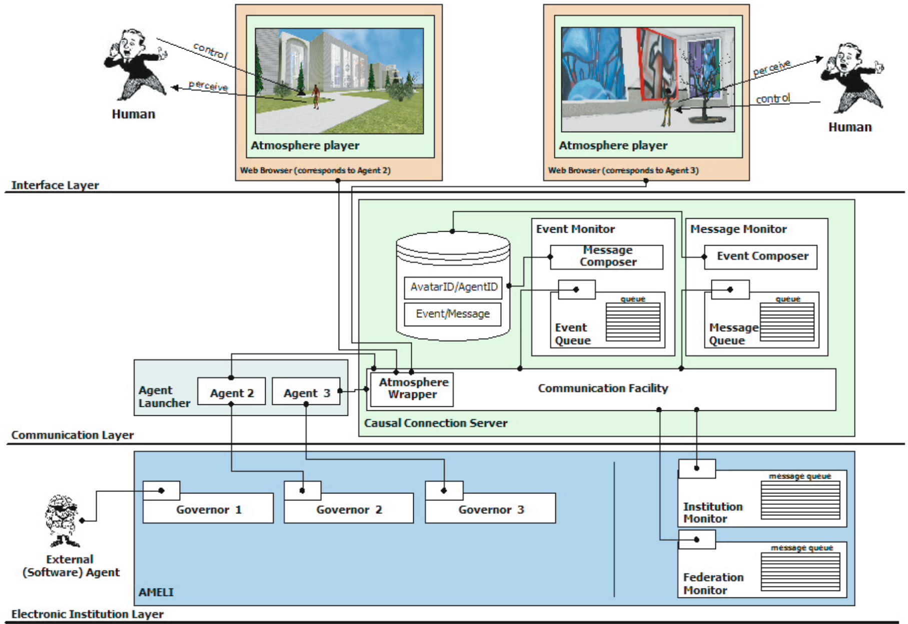

Fig. 2. System architecture of 3D Electronic Institutions

of behavior are enforced. This view permits that agents behave autonomously and make their decisions freely up to the limits imposed by the set of norms of the institution [4]. 3D Electronic Institutions broaden this view and are environments that enable humans to participate in a heterogenous society of individuals. The essence is to step beyond the agents view on Electronic Institutions, take a *human centered* perspective and concentrate on the relation between humans and agents in the amalgamation of the two metaphors.

Basically, 3D Electronic Institutions are built according to a three-layered framework [17]. The system architecture following this framework is depicted in Figure 2. The bottom layer hosts the runtime environment AMELI for arbitrary Electronic Institutions that are designed with ISLANDER [18], a graphical specification tool. Both, AMELI and ISLANDER, are part of the Electronic Institution Development Environment, EIDE [19]. AMELI loads an institution specification and mediates agents interactions while enforcing institutional rules and norms. To execute an Electronic Institution, AMELI is launched up-front and agents join the institution by connecting to the runtime environment.

The second layer contains the *Causal Connection Server* that *causally* connects the Electronic Institutions runtime environment AMELI with the 3D Virtual World at the top layer. As Maes et al. point out in [20], is a system "causally connected" to its representation when the following aspects are taken into account: First, whenever the representation of a system is changed, the system itself has to change as well. Second, whenever the system evolves, its representations has to be modified in order to maintain a consistent relationship. The

Electronic Institution execution itself is represented in terms of a 3D Virtual World consisting of rooms, avatars, doors and other graphical elements. So, the causal connection needs to materialize in two directions. First, messages uttered by the agent in the institution have immediate impact on the 3D representation. Movements between scenes, for instance, must let the avatar "move" within the Virtual World accordingly. Messages uttered by the agent must be considered as uttered by the avatar. Note that in this exposition the terminology of Electronic Institutions is adopted. *Scenes*, are activities following a structured dialogue that agents can engage in. *Transitions* synchronize and re-route agents between scenes. Second, events caused by the human via the interface in the Virtual World are understood as caused by the agent. This implies that actions forbidden to the agent at the current execution state, cannot be performed by the user via the interface. For instance, if an agent is not allowed to leave a particular scene, the avatar is not permitted to open the corresponding door.

Two types of participants need to be considered in 3D Electronic Institutions, namely human users and autonomous software agents. Human users connect to the system via the web interface. The user access is validated and if admission to the institution is granted, the Adobe Atmosphere Player [21] starts and visualizes the 3D Virtual World. At the same time, a message is sent via the Causal Connection Server to the *Agent Launcher* that, in turn, spawns a new software agent. This software agent represents the human user at the Electronic Institution level (cf. Figure 2, the left browser window corresponds to *Agent 2*, the right to *Agent 3*). Each agent participating in an Electronic Institution communicates via a *Governor*. The Governor serves the purpose of "safe-guarding" the institution, i.e. it checks whether a particular message is allowed to be uttered at the current stage or not. The second type of participants are autonomous agents, i.e. software programs, that contact AMELI directly. Each software agent requests access and, if granted, communicates via a Governor as well.

An arbitrary event, e.g. a mouse click on a door handle, caused by a human user leads to a sequence of processing steps. First, the event is caught by the Atmosphere Player and transmitted in terms of a 2–tuple <`AvatarID, Event`> to the Causal Connection Server. Then the event tuple is stored in the *Event Queue* which is observed by the *Event Monitor*. As soon as the Event Monitor notices the arrival, it translates the event by means of the *Event/Message* mapping table into the corresponding message. In analogy to that, the *AvatarID* is mapped onto the *AgentID*, this time though, by means of the *AvatarID/AgentID* mapping table. A 2–tuple <`AgentID, Message`> is composed and stored in the *Message Queue*. This time the *Message Monitor* detects the arrival and sends it to the corresponding agent using the *Communication Facility*. Finally, the agent actually utters the message and the state of the Electronic Institution evolves. AMELI validates whether the received message adheres to the institutional rules and generates an adequate response. Messages, however, originating from AMELI need to be reflected in the Virtual World and are processed in exactly the opposite way.

Fig. 3. The user interface of a 3D Electronic Institution exemplified by means of a graffiti poster shop

The *Institution Monitor*, which offers an interface to AMELI, allows the observation of all messages within a single Electronic Institution. More precisely, the Causal Connection Server is connected to a socket provided by the Institution Monitor, and collects available messages. These messages assist in maintaining the synchronized and consistent relation between the 3D Virtual World and the Electronic Institution. Consider, for example an autonomous software agent that intends to enter the EI (cf. external agent in Figure 2). This particular software agent is not driven by a human user, i.e. it is not required to visually represent the agent for its own sake. However, taking the presence of human participants into account this software agent needs to be visualized as well. So, the Causal Connection Server generates such a representation and assembles it based on the messages obtained via the Institution Monitor. However, since more than one EI might be executed at one time, the *Federation Monitor* notifies about newly launched Electronic Institution. This is rather feasible since movements between Electronic Institutions are possible indeed.

Technically speaking, the user interface comprises the Adobe Atmosphere Player, embedded in a HTML page, accessible via web browsers. Events caused by users within the 3D Virtual World are caught and processed with JavaScript. Conceptually, the embodiment of participants in the 3D Virtual World creates additional opportunities to involve people in social interactions just by the fact of their presence. Being aware of someone's position or her/his line of sight allows observing the environmental context of each particular user. The presence of others creates a more open and a less formal environment. People are more likely to engage in conversations if they perceive the social context as well.

The specification of an Electronic Institution is used to obtain a 3D representation. However, this specification does not contain explicit information related to the visualization of Electronic Institutions. Nevertheless, it is possible to generate a simple 3D Virtual World by exploiting available data. In a straightforward approach, scenes are mapped onto rooms, transitions between scenes are represented as corridors and doors limit the access between scenes. The maximum number of participants per scene determines the size of each room. Doors are positioned in order to connect adjacent rooms. Such an institution is already fully functional, i.e. all security issues are imposed, agents are free to join the environment, interact and engage in conversations.

Figure 3 exemplifies a possible visualization of a 3D Electronic Institution. This particular example features a virtual poster shop that imitates the atmosphere of a real-world art gallery. The gallery's visitors are embodied as avatars. Visitors communicate with each other via the chat window at the bottom of the interface. A transparent institution map, i.e. the layout of the gallery, overlays the Virtual World and is placed at the top right corner of the interface. The large cuboids in the map represent rooms and smaller ones correspond to connections between these rooms. The avatar's position within the institution is symbolized by means of a highlighted figure having an arrow pointing at it. All other figures identify avatars controlled by software agents. These avatars act on behalf of the user and try to fulfill specified tasks. However, only one avatar is actually controlled and driven by the human at one time. This example illustrates the heterogeneity of 3D Electronic Institutions since the two possible types of participants are present. The artist, for instance, is engaged in a conversation with a potential (human) buyer while the software agent (buyer) keeps observing.

5 Conclusion and Future Work

In this paper we presented a novel approach enabling human participation in a Multi-Agent System, namely Electronic Institutions, by means of a 3D Virtual World that materialized in 3D Electronic Institutions. This new environment opens a perfect research playground for heterogenous societies comprising humans and software agents and to examine their relationship in domains such as e-Commerce. Due to the fact that social interaction is crucial in e-Commerce but, however, widely neglected we took up this issue and enabled users to act within the socially augmented context of 3D Virtual Worlds. Since 3D Electronic Institutions allow the specification of arbitrary scenarios, we exemplified its application in terms of an online graffiti poster shop. In this environment users interact with other participants and are able to observe the behavior of their agents as well as to intervene in the agents' decision process if necessary.

We are about to complete the implementation of the system and aim at investigating in detail the co-learning aspects between software agents and their principals. Additionally, we plan to conduct an extensive usability study that evaluates the acceptance and feasibility of this new environment. We expect to obtain new insights about the relationship between humans and agents that assist in future developments.

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