An Agent-based centralized e-Marketplace in a Virtual Environment

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Abstract

In this paper we present the design and implementation of an agent-mediated B2C e-Marketplace as part of the social and immersive 3D e-Tourism environment "Itchy Feet". Customers are able to interact in an intuitive way in the 3D environment and assess tourism products prior to purchase. The e-Marketplace provides services via autonomous software agents for the entire purchase cycle. Fair trade among agents is ensured by regulating the environment with Electronic Institutions.

I. Introduction

Electronic Marketplaces (EMs) are electronic platforms connecting buyers and sellers to conduct business. Wang et al. [10] did a comprehensive literature review of EM research and ascertained that most economic researchers studied decentralized electronic markets but paid less attention to central platforms. Fisher and Craig [5] discovered that the lack of social interaction in online channels and the conflict between online and traditional channels are crucial issues that hinder the adoption of EMs. Furthermore it is important to enforce security mechanisms within a marketplace to ensure fair trade. To address these aspects our work concentrates on the creation of a central platform in the B2C domain. The platform consists of a Multi-Agent System to form and regulate the marketplace, a virtual environment to encourage user participation and communication facilities to support the formation of a community. The whole marketplace is modeled in the virtual environment. We intend to leverage 3D visualization for the presentation of products within the virtual environment. This opens new possibilities for providers to present their products and consumers are able to get more insights than with text and picture only presentations. To establish a sustainable

community we provide a common meeting place for users to communicate and interact with each other. To encourage trust and security we apply Electronic Institutions (EIs) to regulate the marketplace. Electronic Institutions are a Multi-Agent System methodology and provide a facility for defining and regulating interactions between software agents [4]. In our previous work we have connected EIs to a 3D Virtual World to form the 3D e-Tourism environment "Itchy Feet" [2], [7]. Itchy Feet has been developed as part of a project in the tourism domain with the principal goal of creating a 3D e-Tourism environment to support the complex interaction patterns of providers and consumers in e-Tourism. Autonomous software agents are used to render the environment information rich and EIs are used to regulate the actions of all participants.Software agents and users participate in the system and are visualized in the 3D Virtual World.

In this paper the final trading mechanisms of Itchy Feet are presented and special focus is placed on the realization of the auction process. The remainder of this paper is structured as follows. In Section II the related work is presented. Electronic Institutions and the Itchy Feet project are presented in Section III. The marketplace is presented in Section IV and Section IV-B illustrates how auctions are conducted in the 3D Virtual World. In Section V the paper is concluded and an outlook on future work is given.

II. Related Work

Mavetera and Kadyamatimba created a conceptual framework for agent-mediated trading in e-Markets [6]. They identified several stages and components such as product brokering, negotiation and contract formation that are needed to implement a full e-Market system using agent technology. Wang et al. [10] did a comprehensive literature review on the current EM research. They identified eight major research themes and showed that most

studies address only the potential but not the real impact of EMs. Furthermore, the results indicated that most of the research methodologies are rather "qualitative" than "quantitative".

3D Virtual Worlds have been used in research for the past 10 years and several researchers have worked on the more specific topic of combining Multi-Agent Systems and 3D Virtual Worlds. Smith et al. [8] present an approach where the agent logic is incorporated in a 3D environment. According to the authors most worlds are largely static and objects are used to trigger pre-programmed behavior. Agents are supposed to enrich the world and should make the environment more dynamic. The proposed framework consists of a society of agents in which each agent controls a 3D object. Adobbati et al. [1] present GameBots; a system that abstracts from the Multi-Agent System and provides a uniform interface to the 3D Virtual World. The created environment is a multi-agent research test bed that is not limited to a specific task in a fixed environment and supports human testing and interaction. Traum & Rickel [9] studied dialogue models between humans and software agents in 3D Virtual Worlds. They concentrated on issues such as proximity and attentional focus of others, the interplay between speech and nonverbal signals and the ability to maintain multi-part conversations.

III. Framework Description

In Itchy Feet, Electronic Institutions are connected to a 3D Virtual World in order to allow human users to participate in the agent system and to enable the visualization of software agents in the 3D Virtual World. The concept of EIs as well as the framework connecting them to the 3D Virtual World are presented in the following.

A. Electronic Institutions

Electronic Institutions resemble real-world institutions by using formal specifications to define interaction patterns between agents [4]. These specifications describe what agents are eligible to do within an EI. The building blocks of EIs are i) the *Dialogical Framework*, ii) the *Performative Structure*, and iii) the *Norms* and behavioral rules. The *Dialogical Framework* defines the ontology and social structure within the EI. The *Performative Structure* comprises scenes and transitions. Every scene has a protocol that defines the possible interaction patterns among agents within that scene. Scene protocols are defined as finite state machines. A state change is performed when an agent utters a message or a timeout occurs. It is possible to define which agents are eligible to join or leave the scene in which states. Scenes are connected by transitions. Whenever an agent leaves a scene it needs to traverse a

transition to get to the next scene. Transitions may impose restrictions on the movement of an agent. Norms, i.e. the behavioral rules, establish role-based conventions that are used to verify if interacting agents behave according to the system's normative specification. A detailed description of EIs is given in [4].

B. 3D Electronic Institution Framework

In Itchy Feet two types of participants need to be considered: humans and agents. Agents are either autonomous or controlled by a human user. In the latter case, the couple human/agent is represented as an avatar in the 3D Virtual World. The user delegates tasks such as information gathering or product purchasing to the agent and learns from the agent which rules and restrictions apply in the environment. The user must act according to these rules. The movement and actions of the user in the 3D Virtual World are verified by the agent in the EI. Autonomous agents must be visualized in the 3D Virtual World such that users are able to interact and learn from them. The visualization of autonomous agents depends on their task. For example, an agent that actively participates in conversations may be visualized as an avatar, whereas a simple information agent may be visualized as an information monitor. The dependence between the two systems requires that the 3D Virtual World is causally connected to the EI. In our case this means that whenever the 3D Virtual World changes, the EI must change as well. Whenever the EI evolves, the 3D Virtual World has to be modified in order to maintain a consistent relationship. Conceptually speaking, the system is composed of three layers. The 3D Virtual World is located at the top layer, the EI is located at the bottom layer and both components are causally connected by the middleware [3], [7]. A detailed description of the system architecture can be found in [7].

IV. The Itchy Feet Marketplace

Electronic Institutions are a useful framework for the creation of an agent-based e-Marketplace. They enable the participation of heterogeneous autonomous software agents and define a regulatory environment that governs the actions of these agents. However, the ability for human users to engage in EIs is rather limited. In order to overcome these limitations the 3D Virtual World is used as an alternative user interface for end users. The fact that the user is participating in the Multi-Agent System is hidden by the framework and the user is only presented with those interface controls that are necessary to complete the user's goals. The 3D Virtual World of Itchy Feet is composed of three buildings which offer various services to the users. The product trade takes place in the Travel

Agency and Auction House buildings. Products are traded in two different ways: in the Travel Agency the user buys products for a fixed price while in the Auction House the user purchases a product within an auction. Every building is a separate sub-marketplace and the product purchase needs to be completed within the boundaries of this sub-marketplace. For example, the user is only allowed to leave the building if all the products in the user's shopping cart have been paid. This mechanism enables the support of multiple sub-marketplaces that can be defined by different providers to suit the needs of each individual provider. The third building, the Forum building, is the meeting place of Itchy Feet. In this building users are able to hang out, they can share their knowledge and they are able to get help from expert users. An overview of the 3D Virtual World with the three buildings, including a detailed picture of the Auction House, is shown on the left side of Figure 1. The functionality which is available in these buildings is defined in the Multi-Agent System. Every building corresponds to exactly one Electronic Institution. The scenes of an EI are visualized as rooms inside the building and the transitions are visualized as doors connecting these rooms. Whenever the user moves around in the 3D Virtual World, the user's agent mimics the movement in the EI. Since there is no possibility to regulate inter-Electronic Institution communication, a separate EI named `Ether` has been designed. In contrast to the other EIs, the `Ether` is not mapped to a building in the 3D Virtual World. The `Ether's` functions are accessible at every location in the 3D Virtual World and include the shopping cart, the inventory and the chat. Note that agent role names are henceforth formatted in italic. The term *User* refers to the role in the EI that can be played by a software agent as well as a human user. In contrary the term "user" refers to an actual human user that is participating in Itchy Feet via the 3D Virtual World.

A. The Auction Protocol

The `Auction House` EI along with the `Travel Agency` EI constitute the e-Marketplace of Itchy Feet. The `Auction House` comprises six scenes: the offering scene, the information scene, the clearing scene and three auction scenes. The offering scene, lead by the *OfferManager*, is the control unit of the `Auction House`. The *Offer-Manager* overlooks the commodity flows and ensures that every product is put on auction at the scheduled time. *Users* inform themselves about available products in the information scene and pay for auctioned products in the clearing scene. Two types of agents, namely *User* and *Auctioneer*, participate in the auction scene. The possible interactions between these agents are determined by the auction scene protocol.

Prior to the auction start, the *OfferManager* hands over the product to the *Auctioneer*. As soon as the *Auctioneer* receives the product, it informs all agents in the scene that the auction will start. The process is based on a real world English auction, resembling a forward auction starting at a low price where bidders raise the price until no further bids are issued or the bidding time has exceeded. Just like in a real world auction the *Auctioneer* announces the three different states "going once", "going twice" and "sold". An auction ends in one of three different ways: i) a bid has been issued and the *Auctioneer* announces "going once", "going twice" and "sold" without another bid from a different *User* being placed, ii) the bidding time has elapsed making the last *User* which issued a bid the winner, iii) the bidding time has elapsed and no bids have been issued. In any of these cases the *Auctioneer* informs the *OfferManager* whether the product was sold or not. After an auction has ended the *Auctioneer* remains in a waiting state until it receives another product from the *OfferManager*.

B. Auctions in the 3D Virtual World

The auction scene is visualized as a separate room of the Auction House in the 3D Virtual World. The auction room as well as the auction interface are shown on the right side of Figure 1. The auction interface shows the item to be auctioned, the current status of the auction and contains an input box where the next bid is entered. The screenshot shows four actors which are participating in the auction. Two of them are autonomous software agents and two of them are human users who are logged in the 3D Virtual World. The autonomous software agents are visualized by the 3D Virtual World. The roles of these agents determine how and where they are visualized. The *Auctioneer* agent, which is responsible for conducting the auction, is visualized on the stage behind the podium. The other autonomous agent is playing in the *User* role and is also interested in buying the product. This agent is visualized among the other users and is wearing the robot-like outfit. The different locations and outfits of each agent role help the user to quickly identify the duties of each avatar and make it easier to differentiate the individual avatars.

The upcoming auctions are displayed on an information panel in the information room of the Auction House. When a user decides to participate in an auction, she enters the auction room. As a consequence the user's agent enters the auction scene in the EI. The *Auctioneer* starts the auction at the given time following the auction protocol. When a bid is submitted by the user, a request is sent to the user's agent, which sends out a bid message in the auction scene of the `Auction House` EI. The actions of each
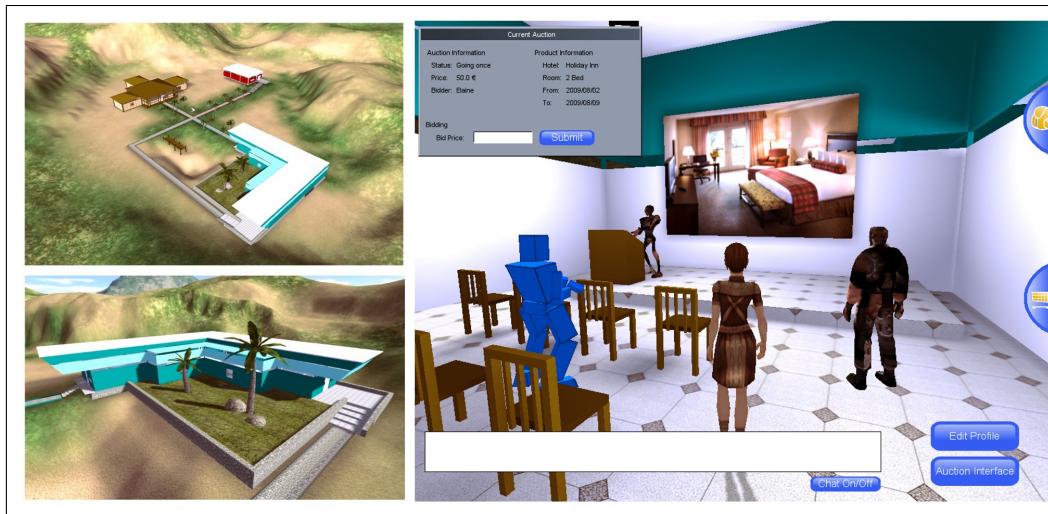
Fig. 1. The 3D Virtual World with the Auction House building and the Auction Room

user and agent are visualized in the 3D Virtual World by gestures and other visual cues. The bidding is illustrated by a hand raising gesture and by a message box with the bid amount that pops up over the avatar. If a user is announced the winner of the auction, the product is displayed in the shopping cart in the 3D Virtual World. The product is then to be paid in the clearing room where the clearing scene is visualized.

V. Conclusion & Future Work

In this work we have utilized 3D Virtual Worlds as a new type of user interface for agent-based e-Marketplaces. The focus was placed on the creation of an easy to use interface enabling end users to participate in Electronic Institutions and to interact with software agents. The marketplace in this environment is realized by means of auctions and fixed price product trade. The trade processes are hereby defined in the EI and autonomous software agents are responsible for their execution. In particular, we have illustrated how auctions are conducted, how the user is able to participate in a natural way and how the connection between the user and the EI works.

The developed system will be used as a test-bed for studying the interaction and behavior of users in an e-Market setting. The next steps of our work involve the execution of user studies where the acceptance of the environment is evaluated.

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