Information Broker Agents in Intelligent Websites

Catholijn M. Jonker, Jan Treur

Vrije Universiteit Amsterdam, Department of Artificial Intelligence
De Boelelaan 1081a, 1081 HV Amsterdam, The Netherlands
URL: http://www.cs.vu.nl/~{jonker,treur}. Email: {jonker,treur}@cs.vu.nl

Abstract. In this paper a generic information broker agent for intelligent Websites is introduced. The agent architecture has been designed using the compositional development method for multi-agent systems DESIRE. The use of the architecture is illustrated in an Electronic Commerce application for a department store.

1   Introduction

Most current business Websites are mainly based on navigation through the available information across hyperlinks. A closer analysis of such conventional Websites reveals some of their shortcomings. For example, customer relations experts may be disappointed about the *unpersonal treatment* of customers at the Website; customers are wandering around anonymously in an unpersonal virtual environment and do not feel supported by anyone. It is as if customers are visiting the physical environment of a shop (that has been virtualised), without any serving personnel.

Marketing experts may also not be satisfied by the Website; they may disappointed in the lack of facilities to support *one-to-one marketing*. In a conventional Website only a limited number of possibilities are provided to announce new products and special offers in such a manner that all relevant customers learn about them. Moreover, often Websites do not acquire information on the amounts of articles sold (sales statistics). It is possible to build in monitoring facilities with respect to the amount of products sold over time, but also the number of times a request is put forward on a product (demand statistics). If for some articles a decreasing trend is observed, then the Website could even warn employees so that these trends can be taken into account in the marketing strategy. If on these aspects a more active role would be taken by the Website, the marketing qualities could be improved.

The analysis from the two perspectives (marketing and customer relations) suggests that Websites should become more active and personalised, just as in the traditional case where contacts were based on humans. Intelligent agents provide the possibility to reflect at least a number of aspects of the traditional situation in a simulated form, and, in addition, enables to use new opportunities for, e.g., one-to-one marketing, integrated in the Website.

In this paper it is shown how a generic broker agent architecture can be exploited to design an intelligent Website for a department store. In Section 2 the application domain is discussed; two types of information agents participating in the application are distinguished. In Section 3 their characteristics and required properties are discussed. In Section 4 the generic broker agent architecture is described and applied to obtain the internal structure of the agents involved in the application.

2 Application: an Intelligent Website for a Department Store

The application addresses the design of an active, intelligent Website for a chain of department stores. The system should support customers that order articles via the Internet. Each of the department stores sells articles according to departments such as car accessoires, audio and video, computer hardware and software, food, clothing, books and magazines, music, household goods, and so on. Each of these departments has autonomy to a large extent; the departments consider themselves small shops (as part of a larger market). This suggests a multi-agent perspective based on the separate departments and the customers. Four types of agents are distinguished:

- *customers* (human agents)
- *Personal Assistant agents* (an own software agent for each user)
- *Department Agents* (software agents within the department store's Website)
- *employees* (human agents)

A Personal Assistant agent serves as an interface agent for the customer. As soon as a customer visits the Website, this agent is offered and instantiated to the customer. The Personal Assistant is involved in communication to both its own user and all Website agents. From the user it can receive information about his or her profile, and it can provide him or her with information assumed interesting. Moreover, it can receive information from any of the Website agents, and it can ask them for specific information. The Website agents communicate not only with all Personal Assistants, but also with each other and with employees. The customer only communicates with his or her own Personal Assistant.

3 Requirements for the Department Agents

The departments should relate to customers like small shops with personal relationships to customers. The idea is that customers know at least somebody (a Department Agent) related to a department, as a representative of the department and, moreover, this agente knows specific information on the customer. Viewed from outside the basic agent behaviours *autonomy*, *responsiveness*, *pro-activeness* and *social behaviour* such as discussed, for example in [10] provide a means to characterise the agents (see Table 3). In addition the interaction characteristics as shown in Tables 1 and 2 have been specified.

Interaction with the world	Department Agent
observation passive	- its own part of the Website - product information - presence of customers/PAs visiting the Website
observation active	- economic information - products and prices of competitors - focussing on what a specific customer or PA does - search for new products on the market
performing actions	- making modifications in the Website (e.g., change prices) - showing Web-pages to a customer and PA - creating (personal or general) special offers - modification of assortment

Table 1. World interaction characteristics for a Department Agent

Communication	Department Agent
incoming	*from PA*: - request for information - request to buy an article - paying information - customer profile information - customer privacy constraints *from Employee*: - requests for information on figures of sold articles - new product information - proposals for special offers and price changes - confirmation of proposed marketing actions - confirmation of proposed assortment modifications - proposals for marketing actions - proposals for assortment modifications *from other DA*: - info on assortment scopes - customer info
outgoing	*to PA*: - asking whether DA can help - providing information on products - providing information on special offers - special (personal or general) offers *to Employee*: - figures of articles sold (sales statistics) - analyses of sales statistics - numbers of requests for articles (demand statistics) - proposals for special offers - proposals for assortment modifications *to other DA*: - info on assortment scopes - customer info

Table 2. Communication characteristics for a Department Agent

The following requirements have been imposed on the Department Agents:

- *personal approach; informed behaviour with respect to customer*
  In the Website each department shall be represented by an agent with a name and face, and who knows the customer and his or her characteristics, and remembers what this customer bought previous times.
- *being helpful*
  Customers entering some area of the Website shall be contacted by the agent of the department related to this area, and asked whether he or she wants some help. If the customer explicitly indicates that he or she only wants to look around without getting help, the customer shall be left alone. Otherwise, the agent takes responsibility to serve this customer until the customer has no wishes anymore that relate to the agent's department. The conventional Website can be used by the Department Agents to point at some of the articles that are relevant (according to their dialogue) to the customer.
- *refer customers to appropriate colleague Department Agents*
  A customer which is served at a department and was finished at that department can only be left alone if he or she has explicitly indicated to have no further wishes within the context of the entire department store. Otherwise the agent shall find

out in which other department the customer may have an interest and the customer shall be referred to the agent representing this other department.

- *be able to provide product and special offer information*
  For example, if a client communicates a need, then a product is offered fulfilling this need (strictly or approximately), and, if available a special offer.
- *dedicated announcement*
  New products and special offers shall be announced as soon as available to all relevant (on the basis of their profiles) customers, not only if they initiate a contact with the store, but they also shall be contacted by the store in case they do not contact the store

Basic types of behaviour	Department Agent
Autonomy	- functions autonomously, especially when no employees are available (e.g., at night)
Responsiveness	- responds to requests from Personal Assistants - responds to input from Employees - triggers on decreasing trends in selling and demands
Pro-activeness	- takes initiative to contact Personal Assistants - takes initiative to propose special offers to customers - creates and initiates proposals for marketing actions and assortment modifications
Social behaviour	- cooperation with Employees, Personal Assistants, and other Department Agents

Table 3. Basic types of behaviour of a Department Agent

- *analyses for marketing*
  The Department Agents shall monitor the amounts of articles sold (sales stastitics), communicate them to Employees (e.g., every week) and warn if substantially decreasing trends are observed. For example, if the figures of an article sold decrease during a period of 3 weeks, thenmarketing actions or assortment modifications shall be proposed.
- *actions for marketing*
  Each Department Agent shall maintain the (history of) the transactions of each of the customers within its department, and shall be willing to perform one to one marketing to relevant customers, if requested. The Employees shall be able to communicate to the relevant Department Agents that they have to perform a marketing campaign. The agent shall propose marketing actions to Employees.
- *privacy*
  No profile is maintained without explicit agreement with the customer. The customer has access to the maintained profile.

3.2   Characteristics and Requirements for the Personal Assistants

For the Personal Assistants the interaction characteristics are given in Table 4, and their basic types of behaviour in Table 5. The following requirements can be imposed on the Personal Assistants:

- *support communication on behalf of the customer*
  Each customer shall be supported by his or her own Personal Assistant agent, who serves as an interface for the communication with the Department Agents.
- *only provide information within scope of interest of customer*
  A customer shall not be bothered by information that is not within his or her scope of interest. A special offer that has been communicated by a Department Agent leads to a proposal to the Customer, if it fits in the profile, and at the moment when the Customer wants such information
- *sensitive profiling*
  Customers are relevant for a special offer if they have bought a related article in the past, or if the offer fits in their profile as known to the Personal Assistant.
- *providing customer information for Department Agents*
  every week the relevant parts of the profile of the Customer is communicated to the Department Agent, if the Customer agrees.
- *privacy*
  The Personal Assistant shall protect and respect the desired privacy of the customer. Only parts of the profile information agreed upon are communicated.

Interaction characteristics	Personal Assistant
A. Interaction with the world	
observation passive observation active	- notice changes and special offers at the Website - look at Website for articles within the customer needs
performing actions	
B. Communication with other agents	
incoming	*from Department Agent*: - product info - special (personal and general) offers *from Customer*: - customer needs and preferences - agreement to buy - privacy constraints
outgoing	*to Department Agent*: - customer needs - payment information - profile information *to Customer*: - product information - special offers

Table 4. Interaction characteristics for the Personal Assistant

Basic types of behaviour	Personal Assistant
Autonomy	autonomous in dealing with DAs on behalf of customer
Responsiveness	responsive on needs communicated by customer

Pro-activeness	initiative to find and present special offers to customer
Social behaviour	with customer and DAs

Table 5. Basic types of behaviour for the Personal Assistant

4 The Internal Design of the Information Broker Agents

The agents in the application presented in the previous sections have been designed on the basis of a generic model for a broker agent. The process of brokering as often occurs as a mediating process in electronic commerce involves a number of activities. For example, responding to customer requests for products with certain properties, maintaining information on customers, building customer profiles on the basis of such customer information, maintaining information on products, maintaining provider profiles, matching customer requests and product information (in a strict or soft manner), searching for information on the WWW, and responding to new offers of products by informing customers for whom these offers fit their profile. In this section a generic broker agent architecture is presented that supports such activities. This generic model has been used as a basis for both the Department Agents and the Personal Assistant agents.

4.1   A Generic Broker Agent Architecture

For the design of the generic broker agent the following main aspects are considered: process composition, knowledge composition, and relations between knowledge and process composition, as discussed in Section 2. A compositional generic agent model (introduced in [2]), supporting the weak agency notion (cf. [10]) is used; see Fig. 1. At the highest abstraction level within an agent, a number of processes can be distinguished that support interaction with the other agents. First, a process that manages communication with other agents, modelled by the component agent interaction management in Fig. 1. This component analyses incoming information and determines which other processes within the agent need the communicated information. Moreover, outgoing communication is prepared. Next, the agent needs to maintain information on the other agents with which it co-operates: maintenance of agent information. The component maintenance of world information is included to store the world information (e.g., information on attributes of products). The process own process control defines different characteristics of the agent and determines foci for behaviour. The component world interaction management is included to model interaction with the world (with the World Wide Web world, in the example application): initiating observations and receiving observation results.

The agent processes discussed above are generic agent processes. Many agents perform these processes. In addition, often agent-specific processes are needed: to perform tasks specific to one agent, for example directly related to a specific domain of application. The broker agent may have to determine proposals for other agents. In this process, information on available products (communicated by information providing agents and kept in the component maintenance of world information), and about the scopes of interests of agents (kept in the component maintenance of agent information), is combined to determine which agents might be interested in which products. Fig. 1 depicts how the broker agent is composed of its components.

Part of the exchange of information within the generic broker agent model can be described as follows. The broker agent needs input about scopes of interests put

forward by agents and information about attributes of available products that are communicated by information providing agents. It produces output for other agents about proposed products and the attributes of these products. Moreover, it produces output for information providers about interests. In the information types that express communication information, the subject information of the communication and the agent from or to whom the communication is directed are expressed. This means that communication information consists of statements about the subject statements that are communicated.
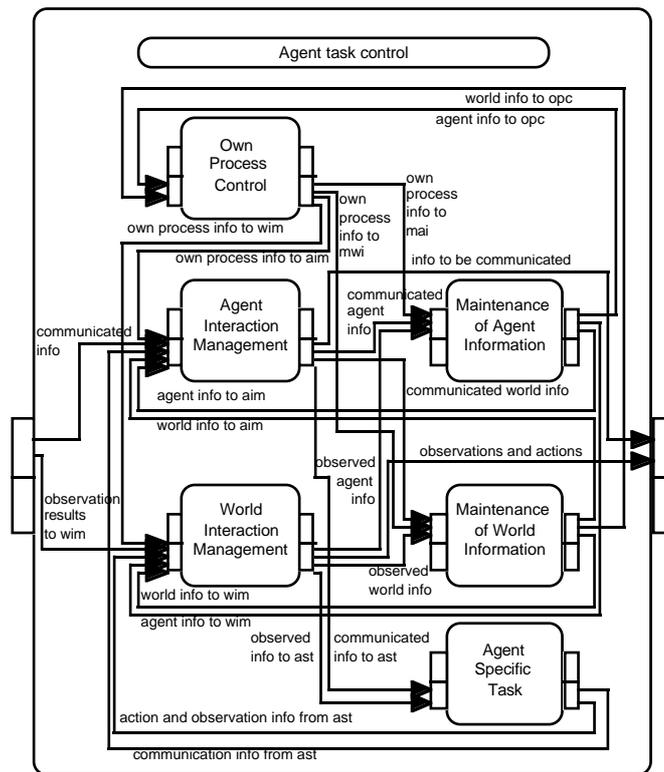

Fig. 1. Composition within the broker agent model

Within the broker agent, the component own process control uses as input belief info, i.e., information on the world and other agents, and generates focus information: to focus on a scope of interest to be given a preferential treatment, i.e., pro-active behaviour will be shown with respect to this focus. The component agent interaction management has the same input information as the agent (incoming communication), extended with belief info and focus info. The output generated includes part of the output for the agent as a whole (outgoing communication), extended with maintenance info (information on the world and other agents that is to be stored within the agent), which is used to prepare the storage of communicated world and agent information.

Information on attributes of products is stored in the component maintenance of world information. In the same manner, the beliefs of the agent with respect to other agents'

profiles (provider attribute info and interests) are stored in maintenance of agent information. The agent specific task uses information on product attributes and agent interests as input to generate proposals as output. For reasons of space limitation the generic and domain-specific information types within the agent model are not presented; for more details; see [5].

4.2 The Department Agent: Internal Design

The broker agent architecture provides an appropriate means to establish the internal design of the two types of agents involved.

For the Department Agent, the internal storage and updating of information on the world and on other agents (the beliefs of the agent) is performed by the two components maintenance of world information and maintenance of agent information. In Table 6 it is specified which types of information are used in these components. Profile information on customers is obtained from Personal Assistants, and maintained with the customer's permission. Also identified behaviour instances of the Personal Assistants can give input to the profile. Profile information can be abstracted from specific demands, using existing datamining techniques.

Maintenance of Information	Department Agent
world information	- info on products within the DA's assortment - info on special offers
agent information	- info on customer profiles - info on customer privacy constraints - info on MA's needs for figures - info on customer preferences in communication - info on which products belong to which other DA's assortments - info on providers of products

Table 6. Maintenance information for the Department Agent

The component agent interaction management identifies the information in incoming communication and generates outgoing communication on the basis of internal information. For example, if a Personal Assistant agent communicates its interests, then this information is identified as new agent interest information that is believed and has to be stored, so that it can be recalled later.

In the component agent specific task specific knowledge is used such as, for example:
- if the selling numbers for an article decrease for 3 weeks, then make a special offer with lower price, taking into account the right season
- if a customer asks for a particular cheap product, and there is a special offer, then this is proposed
- if an article is not sold enough over a longer period, then take it out of the assortment

Within this component non-strict (or soft) matching techniques can be employed to relate demands and offers.

4.3 The Personal Assistant: Internal Design

In this section some of the components of the Personal Assistant are briefly discussed.

For the Personal Assistant, as for the Department Agent, the internal storage and updating of information on the world and on other agents is performed by the two components maintenance of world information and maintenance of agent information. In Table 7 it is specified which types of information are used in these components.

Maintenance of Information	Personal Assistant
world information	- product information - special offers
agent information	- customer needs and profile - customer privacy constraints - offers personal to the customer - DAs assortment scopes

Table 7. Maintenance information for a Personal Assistant

As in the previous section, the component agent interaction management identifies the information in incoming communication and generates outgoing communication on the basis of internal information. For example, if a Department Agent communicates a special offer, then this information is identified as new agent information that is believed and has to be stored, so that it can be recalled later. Moreover, in the same communication process, information about the product to which the special offer refers can be included; this is identified and stored as world information.

6 Discussion

In this paper a multi-agent architecture for intelligent Websites is proposed, based on information broker agents. A Website, supported by this architecture has a more personal look and feel than the usual Websites. Within the architecture, also negotiation facilities (e.g., as in [8]) can be incorporated. The broker agent architecture has also been applied within a project on virtual market environments in Electronic Commerce, in co-operation with the Internet application company Crisp.

Applications of broker agents (addressed in, e.g., [3], [4], [6], [7], [8], [9]), often are not implemented in a principled manner: without an explicit design at a conceptual level, and without support maintenance. The broker agent architecture introduced here was designed and implemented in a principled manner, using the compositional development method for multi-agent systems DESIRE [1]. Due to its compositional structure it supports reuse and maintenance; a flexible, easily adaptable architecture results. Moreover, within the agent model facilities can be integrated that provide automated support of the agent's own maintenance [5]. Therefore, the agent is not only easily adaptable, but, if in such a manner adaptation is automated, it shows adaptive behaviour to meet new requirements (either in reaction to communication with a maintenance agent, or fully autonomous).

References

1. Brazier, F.M.T., Dunin-Keplicz, B., Jennings, N.R., and Treur, J., Formal specification of Multi-Agent Systems: a real-world case. In: V. Lesser (ed.), *Proceedings of the First International Conference on Multi-Agent Systems, ICMAS'95*, MIT Press, Cambridge, MA, 1995, pp. 25-32. Extended version in: *International Journal of Cooperative Information Systems*, M. Huhns, M. Singh, (eds.), special issue on Formal Methods in Cooperative Information Systems: Multi-Agent Systems, vol. 6, 1997, pp. 67-94.

2. Brazier, F.M.T., Jonker, C.M., and Treur, J., Formalisation of a cooperation model based on joint intentions. In: J.P. Müller, M.J. Wooldridge, N.R. Jennings (eds.), *Intelligent Agents III (Proceedings of the Third International Workshop on Agent Theories, Architectures and Languages, ATAL'96),* Lecture Notes in AI, volume 1193, Springer Verlag, 1997, pp. 141-155.

3. Chavez, A., and Maes, P., Kasbah: An Agent Marketplace for Buying and Selling goods. In: *Proceedings of the First International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology, PAAM'96*, The Practical Application Company Ltd, Blackpool, 1996, pp. 75-90.

4. Chavez, A., Dreilinger, D., Gutman, R., and Maes, P., A Real-Life Experiment in Creating an Agent Market Place. In: *Proceedings of the Second International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology, PAAM'97*, The Practical Application Company Ltd, Blackpool, 1997, pp. 159-178.

5. Jonker, C.M., and Treur, J., *Compositional Design and Maintenance of Broker Agents*. Technical Report, Vrije Universiteit Amsterdam, Department of Mathematics and Computer Science, 1998.

6. Kuokka, D., and Harada, L., On Using KQML for Matchmaking. In: V. Lesser (ed.), *Proceedings of the First International Conference on Multi-Agent Systems, ICMAS'95*, MIT Press, Cambridge, MA, 1995, pp. 239-245.

7. Martin, D., Moran, D., Oohama, H., and Cheyer, A., Information Brokering in an Agent Architecture. In: *Proceedings of the Second International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology, PAAM'97*, The Practical Application Company Ltd, Blackpool, 1997, pp. 467-486.

8. Sandholm, T., and Lesser, V., Issues in Automated Negotiation and Electronic Commerce: Extending the Contract Network. In: V. Lesser (ed.), *Proceedings of the First International Conference on Multi-Agent Systems, ICMAS'95*, MIT Press, Cambridge, MA, 1995, pp. 328-335.

9. Tsvetovatyy, M., and Gini, M., Toward a Virtual Marketplace: Architectures and Strategies. In: *Proceedings of the First International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology, PAAM'96*, The Practical Application Company Ltd, Blackpool, 1996, pp. 597-613.

10. Wooldridge, M., and Jennings, N.R., Agent theories, architectures, and languages: a survey. In: [11], pp. 1-39.

11. Wooldridge, M., and Jennings, N.R. (eds.), *Intelligent Agents, Proceedings of the First International Workshop on Agent Theories, Architectures and Languages, ATAL'94*, Lecture Notes in AI, vol. 890, Springer Verlag, 1995.